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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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Engineering Firm, with an up-to-date plant for drop forging, machining, and hardening repetition work, would like to get into touch with anyone to whom their services would be of value after the War. Would also be prepared to consider the putting down of plant for the manufacture of a speciality.—Address, F 225, Offices of Engineering.

Firm in the West Riding of Yorkshire are PREPARED, subject to the approval of the Ministry of Munitions, to GIVE OUT ORDERS for their standard lines of Lathes, 7 in. to 12½ in., and Radial Drills, 3 ft. 6 in. to 6 ft. radius, and would be pleased to hear from firms in Lancashire or Yorkshire who can undertake the manufacture of such machines for reasonable deliveries.—Address, in first instance, F 302, Offices of Engineering.

London Manufacturers of paints and varnishes (specializing in qualities for Engineers and Export), are prepared to APPOINT AGENTS at home and abroad.—B. & B., care of Crawford's, 25, Craven House, Kingsway, London. F 276

Agency Wanted, by Well-known firm of engineers in the Midlands.—Address, F 324, Offices of Engineering.

THE HARNESSING OF THE WINNIPEG RIVER.

(Concluded from page 346.)

Whatever be the total extent of the resources, future projects are to some extent placed at a disadvantage by the action of early forestallers, whose interests have now to be safeguarded. The general policy of the Water Power Board cannot be jeopardised, or even materially affected, by the undertakings already sanctioned; indeed, the existing installations will have rendered a distinct service if they make more prominent the need of rigorous supervision and control by disinterested authorities, who will ensure the treatment of the river power as a single unit, whose entire capacity is to be developed and exhausted for the benefit of the community, preventing waste of national resources. The existing monopolies are not planned on insignificant lines, they are worthy of a progressive community, and evidence skill and enterprise of a high order. The municipal power plant on the main river, and that of the Winnipeg Railway on the Pinawa channel, are permanent, well-considered structures, having

TABLE I.—Particulars of Proposed Power-Stations.

Site.	Distance from Winnipeg in Miles.	Head in feet.	Power Available.			
			24-Hour Power at 75 per cent. Efficiency.		Turbine Installation.	
			12,000 cub. ft. per sec.	20,000 cub ft. per sec.	12,000 cub. ft. per sec.	20,000 cub. ft. per sec.
Pine Falls	64	37	37,900	63,100	6—10,000	10—10,000
Du Bonnet Falls	64	56	57,300	95,500	9—10,000	14—10,000
McArthur Falls	62	18	18,400	30,700	11— 2,500	17— 2,500
Lower Seven Sisters	52	37	12,600	37,900	—	6—10,000
Upper Seven Sisters	55	29	9,900	29,600	—	8— 6,000
Upper Pinawa	58	18	12,300	12,300	4— 4,500	4— 4,500
Slave Falls	74	26	26,600	44,400	8— 5,000	13— 5,000
Total	..	.. ..	175,000	313,500	235,500	473,500

efficiently. In future development it is proposed to utilise this flow at an upper station on the Pinawa, necessitating the replacement of the diversion weirs by a controlled dam.

Of later construction, and of still more imposing dimensions, is the Winnipeg Municipal Plant on the

Fig. 3. Ice Conditions in Pinawa Channel.

an important place in the plans of future development. The earlier established, that of the railway company, is capable of distributing 45,000 h.p., and this amount is not only easily absorbed, but auxiliary steam power and storage battery plant is needed as a supplement. We are only concerned now with the extent and manner of appropriating the water power from the general stock. The site of the power source is situated some 58 miles from the city on the Pinawa channel, a waterway that has already been described as a high-water by-pass between the main river and the Lake du Bonnet. Diversion weirs, which can act as free spillways, have been constructed to raise the water level to a sufficient height to divert the necessary flow down the Pinawa. This discharge is governed by a control dam, above which there is a pondage area of some 5,800 acres in extent. The control dam is 2½ miles above the power-station pond, and a channel or head race has been constructed to convey the water. Along this head race the current is rapid in consequence of a considerable drop in elevation. In this somewhat turbulent current during the winter the conditions are so favourable for the formation of frazil ice that the passage is liable to be choked, and the removal occasionally requires the use of explosives. Still, it is maintained that the experience and promptness of the management prevent any inconvenience. Some of the illustrations, however, look alarming to the unaccustomed eye, and in any case this obstructive ice (see Fig. 3) is no doubt responsible for the variation in the available head, a source of inconvenience. The head is put at 39 ft., and though the data for estimating the flow are somewhat uncertain, it would be unsafe to allow less than 8,000 sec.-ft. to pass in order to operate the plant main river, 75 miles distant from the city. Here there is a natural fall of from 28 ft. to 33 ft., variable owing to want of efficient regulation, that has been increased to 45 ft. Further, the site provides excellent foundation for dams, power-house, &c., and full advantage has been taken of such rigid support. The works are so arranged as to permit of extension and have not yet reached their full development. The city is in possession of a very fine property, and has expended its funds with judicious foresight.

The works have been described in detail in this journal, and it is only necessary to recall that the general plan is arranged, when working at its fullest extent, to draw upon the entire flow of the Winnipeg river. This is a cardinal fact of great importance to be kept in view in all future schemes of development. When the project was designed the lowest recorded flow was 16,000 sec.-ft., and the design of the plant was based on that flow combined with local pondage. In a very few years, however, the discharge fell as low as 11,700 sec.-ft., and we cannot doubt but that this minimum will again be passed when observations have been extended. With sounder judgment and greater experience the authorities have based their scheme on 12,000 sec.-ft. as the minimum flow. It might appear, therefore, that the municipal plant would be over-developed on completion, and with this possibility overhanging, in the interests of the city itself there can be no doubt of the wisdom of proceeding with a scheme that by vigorous and systematic regulation of the river would increase the flow to 20,000 sec.-ft. To effect such an available increase is an economic work of vital importance that should not be delayed.

Relying on such a supply with a 45-ft. head, the turbine installation designed would give 83,200 24-hour h.p., and with the advantages of a 6,500 acre pond the actual power available on a peak load would far exceed that quantity. A four-hour peak of 125,000 h.p. would draw on the local pondage to the extent of 0·6 ft. only, and this is considered practicable, provided the 20,000 sec.-ft. minimum is attained.

There are other hydro-electric stations working in the basin that must be considered in a general control. In the neighbourhood of Kenora, on the eastern outlet from the Lake of the Woods, small undertakings are being increased in size, and, far to the south, Fort Frances on Rainy Lake, and other sites on Lake Namaquam, though remote, have interests that have not been ignored in the comprehensive plan which may now be sketched.

Bearing in mind these restrictions, and that the river is classed as a navigable stream, requiring that the provisions of the "Navigable Waters Protection Act" must be observed, the power available is still very considerable. We are not justified in including the resources of the English river and of Lac Seul, for though these are at an easily accessible distance from Winnipeg, the Province of Ontario has the first claim to them. There remains practically the entire unused river fall in Manitoba between Lakes Winnipeg and Du Bonnet, with some additional developments on the loop between the Point du Bois falls and the southern side of the Du Bonnet Lake. It is suggested that along these two branches of the river the power can be conveniently and economically concentrated into seven stations, as already mentioned, with a minimum output of 175,000 continuous 24-hour h.p. under present conditions of flow, and of a possible 313,000 h.p. with the river regulated to 20,000 sec.-ft. minimum (see Fig. 4, page 374). The prime details connected with these stations, intended to give, on full development, more than 420,000 h.p., can best be exhibited in tabular form, as given above in Table I.

No installation is given for the Lower and Upper Seven Sisters site, with 12,000 sec.-ft. discharge, because it will not be profitable to proceed with the development of the Seven Sisters reach until such time as the river has been regulated and the 20,000 sec.-ft. made available for use. The remaining items of the table call for no remark.

The estimates of cost and the deductions as to the price per horse-power must, of necessity, be approximate. It is not intended that the designs and lay-out proposed and the equipment suggested should be rigidly adhered to as final contracts, but the basic elements depending upon head and tail water elevations, discharging capacity and stability of dams, sufficiency of power-houses and contingent structures, will be maintained as proposed in the interests of the complete river development scheme. Owing to this elasticity in minor matters, the design and estimates have been worked out only in sufficient detail to permit a fairly accurate estimate of the quantities and costs involved. As a rule, too, no allowance has been made for transformation and transmission. The costs represent the approximate capital expenditure to place the power on the low-tension switchboard at each station. With these reservations, Table II, page 374, will be intelligible.

In consequence of the intentional over-development at each site, the unit costs have been exhibited in terms of the horse-power installed, as well as in terms of 24-hour power. From either calculation the advantageous position occupied by the Du

Table II.—Estimated Cost of Proposed Power Stations.

Site.	Capital Cost on Low-Tension Switchboard.					
	Total.	Cost.	Per Horse-power on Basis of 75 per cent. Efficiency, 24 h.p.		Per Horse-power on basis of Installation.	
	12,000 cub. ft. per sec.	20,000 cub. ft. per sec.	12,000 cub. ft. per sec.	20,000 cub. ft. per sec.	12,000 cub. ft. per sec.	20,000 cub. ft. per sec.
	Dols.	Dols.	Dols. Cents.	Dols. Cents.	Dols. Cents.	Dols. Cents.
Pine Falls	3,057,000	4,407,000	80 66	69 84	50 95	44 07
Du Bonnet Falls	4,624,000	6,551,000	80 79	68 60	53 80	46 79
McArthur Falls	2,031,000	2,740,000	110 38	89 25	73 88	64 47
Lower Seven Sisters	—	3,409,000	—	89 95	—	56 82
Upper Seven Sisters	—	2,724,000	—	92 03	—	56 75
Upper Pinawa	1,280,000	1,280,000	104 07	104 07	71 11	71 11
Slave Falls	2,327,000	3,436,000	87 50	77 39	58 20	52 86
Total	13,319,000	24,547,000	—	—	—	—
Mean (Based on power output.)	—	—	87 30	78 30	56 60	42 80

sure of their ground, for they make and recommend no provision for auxiliary plant to bridge over times of low water or break-down of machinery. Damage to the transmission line or accident to the generating plant are losses that are certain to occur sooner or later, and can be provided against by duplication; but these annoyances, particularly irritating when interrupting lighting or traction machinery, do not arise from a generically defective system. One may have, however, a valuable commodity, certain in action and readily produced, and yet find that, owing to local circumstances or the necessities of manufacture, he can be undersold by competing producers. Such instances occur, for example, when it is advantageous to generate gas from cheap coal, or cheaper peat, for fuel as well as for power, obtaining perhaps some further compensation from by-products. The compilers of this comprehensive survey have considered possible competition with other sources of power, and made careful comparison

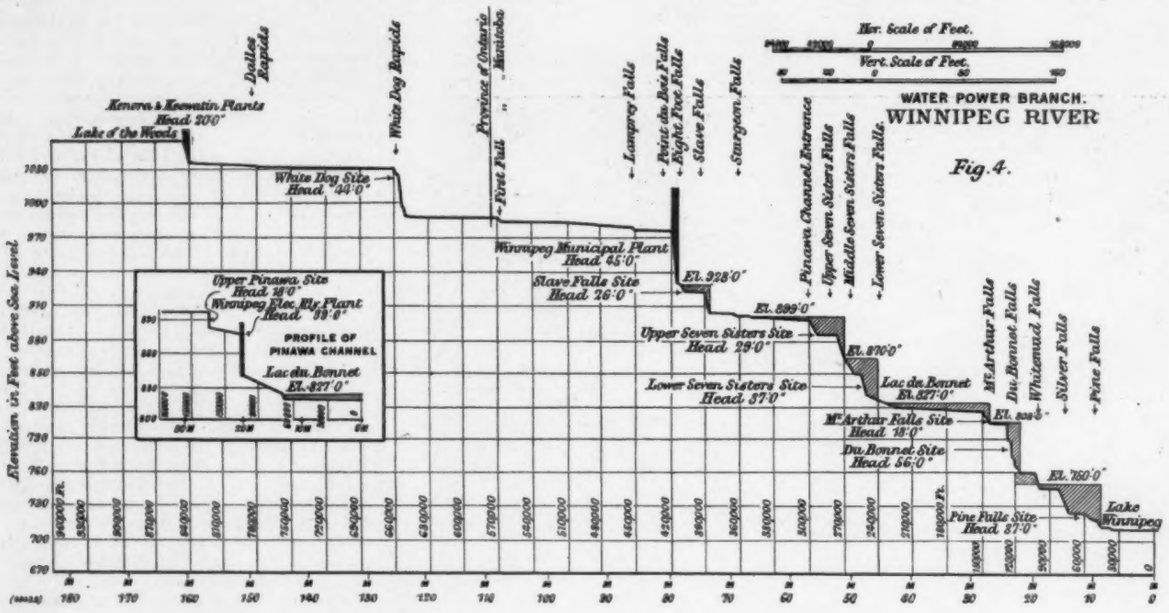


Fig. 4. Illustrating the Use of a Large Body of Water with Small Vertical Fall.

Bonnet site, due to the high head of 56 ft., is apparent. The capital cost of $68·60 per horse-power compares very favourably with that of the McArthur Falls, where, on account of the low head, in conjunction with the long dam and headworks required, the cost rises to $89.25 per horse-power. Under a higher regulated flow the two Seven Sisters and the Upper Pinawa sites are to be regarded as very attractive commercial propositions.

The annual operating costs are to a certain extent tentative, and experience would teach us to scrutinise them closely. They appear moderate, but Mr. Johnston points out that they represent conditions which probably would not obtain upon the immediate completion of the undertakings. On the other hand, some compensation may be expected from the ample pondage that exists, permitting a very heavy peak load to be carried for short intervals. Table III, annexed, shows the approximate figures.

Manitoba is to be congratulated on possessing a fine property, presumably of easy development, and one that will stimulate the prosecution of all industries that require cheap power. A contemplated expenditure of 25 million dollars does not frighten a progressive colony, and such an outlay will be wise if it excludes the interference of the capitalist middleman between the original water-power and the consumer. But it must be remembered that the provision of cheap power does not solve all problems. There have been cases in which it has been preferable to pay higher for current from a more distant source than to use that near at hand, when the cheaper was hampered by frequent interruptions and expensive disturbances. Here, again, the engineers seem

Table III.—Estimated Costs of Operating Proposed Power Stations.

Site.	Annual Operation Cost on Low-Tension Switchboard.					
	Total Annual Cost.		Per Horse-power on Basis of 75 per cent. Efficiency, 24 h.p.		Per Kilowatt-hour 100 per cent. Load Factor.	
	12,000 cub. ft. per sec.	20,000 cub. ft. per sec.	12,000 cub. ft. per sec.	20,000 cub. ft. per sec.	12,000 cub. ft. per sec.	20,000 cub. ft. per sec.
	Dols.	Dols.	Dols. Cents.	Dols. Cents.	Cents.	Cents.
Pine Falls	303,000	447,000	8 0	7 8	0.122	0.108
Du Bonnet Falls	433,000	635,000	7 56	6 65	0.116	0.102
McArthur Falls	199,000	272,000	10 82	8 86	0.166	0.136
Lower Seven Sisters	—	328,000	—	8 65	—	0.132
Upper Seven Sisters	—	268,000	—	9 05	—	0.138
Upper Pinawa	128,000	128,000	10 40	10 40	0.159	0.159
Slave Falls	228,000	338,000	8 58	7 62	0.131	0.117
Total	1,291,000	2,416,000	—	—	—	—
Mean (based on power output)	—	—	8 47	7 71	0.130	0.118

Table IV.—Table Showing Comparative Costs of Fuel-Power in Winnipeg with Power from Pine Falls for a Plant of 500 H.P.

—	Capital Cost Installed Complete.	Per Horse-power Year. Load Factor.			Per Kilowatt-hour. Load Factor.		
		25 per cent.	50 per cent.	75 per cent.	25 per cent.	50 per cent.	75 per cent.
	Dols.	Dols. Cents.	Dols. Cents.	Dols. Cents.	Cents.	Cents.	Cents.
Steam	42,500	52 50	87 50	115 0	3.22	2.68	2.32
Diesel oil	55,000	35 50	55 50	75 50	2.18	1.70	1.54
Producer gas	50,000	42 50	70 0	97 0	2.60	2.13	1.97
Hydro-Electric—							
12,000 cub. ft. per sec.	12,000	15 0	15 35	15 70	0.66	0.57	0.54
20,000 cub. ft. per sec.	12,000	13 30	13 70	14 10	0.60	0.51	0.48

between the cost of hydro-electric power in Winnipeg and that of fuel power from other sources, as steam, Diesel oil machines, and producer gas. Natural gas is not available. The results, based on colonial prices of labour and materials, being interesting, are exhibited in Table IV, annexed. They refer to a moderate plant of 500 h.-p., and the costs include the interest on vested capital, loss by depreciation, and cost of maintenance. In the case of electric plant the power is produced at a typical site and delivered at a terminal station in the city of Winnipeg, transformed down to 2,200 volts pressure. Fuel oil is reckoned at 9 cents per Imperial gallon, and coal (Pittsburg run of the mine bituminous coal) at 6.25 dols. per ton. The capital cost of installation of hydro-electric power is put at 24 dols.; steam at 85 dols.; Diesel oil plant at 110 dols., and producer gas at 100 dols. per b.h.p.

In comparison with fuel power, the electric appears cheap, but is still far dearer than in Norway, where electric energy is supplied at a total cost of 4 to 8 dols. per horse-power year, but it is about the same rate as at Niagara Falls. The price would probably prove prohibitive for the production of fertilisers, of which Manitoba may stand in need in a few years, but could probably be successfully employed in the manufacture of nitric acid, if the cost of transportation permitted such a chemical process to be prosecuted.

Finally, it is immaterial how cheaply electric energy can be produced if there be no market for it, and though it is not possible to establish a fixed ratio between power required and extent of population, it is safe to say that a few years ago the small community of Winnipeg would have had no use for such schemes as that set forth. To-day the conditions are different. In the last ten years the population has more than doubled; there are no signs of a pause in progressive development, and, like other districts in Canada, that of Winnipeg has shown great appreciation of distributed mechanical power. In this respect the position of the Dominion is a proud one. While the ratio of power developed per square mile does not compare with Switzerland, Norway, Italy or Sweden, and other countries smaller in area or more advanced in settlement, in the ratio of power developed to population only Norway occupies a more prominent position. The development per capita for the two countries, Norway and Canada, is respectively 487 and 210 h.p. per 1,000 population. The distribution throughout the Dominion is naturally not uniform, and in Manitoba the ratio falls to 111 per 1,000 population. This smaller average admits of easy explanation. First, the fairly steady discharge of the rivers and their slow but uniform fall do not lend themselves to a cheap and immediate development of power from water, and, secondly, the grouping of the people into industrial centres within easy and convenient transmission of the power sources is more difficult of attainment where agriculture is the main industry. Nevertheless, within the last eight years the load expressed in kilowatt-hours has advanced from 8,000,000 to 136,000,000, and it is a fair inference that in a few decades the entire output from the river can be absorbed by the city alone. That this view is based on a firm foundation is demonstrated by the number of factories that have sprung up, the great railway centre that has developed, and the practically unlimited market for manufactured products that has so rapidly established itself in the centre of the Continent. Mr. J. R. Freeman, the eminent consulting hydraulic engineer, who has helped to forward so many gigantic schemes in the United States, reported in 1911: "While water power opportunities on the Winnipeg river may a very few years ago have appeared so far beyond possible use that ordinary economies were unnecessary, it is, I believe, plain to-day beyond serious question that all of the remaining opportunities for power should be carefully conserved and only developed under such conditions as will not necessitate any great waste or the impairment of remaining opportunities." In this spirit of true economy and judicious foresight the Water Power Branch of Canada has put forth to the world this report, amply illustrated with exact plans, advertising what advantages they have to offer and at the same time demonstrating their fixed intention to carry out an enlightened policy that will safeguard the interests of the people and promote the industrial and commercial prospects of the entire province.

THE BRITISH ASSOCIATION.

(*Continued from page* 349.)

SECTION B.—CHEMISTRY.

Future of the Synthetic Chemical Industry in Great Britain.

Mr. F. H. Carr, F.I.C., of Nottingham, followed the delivery of the President's address with a memoir on "Some Aspects of the Future of the Synthetic Chemical Industry in Great Britain," emphasising, like the president, the question of training.

Since the outbreak of the war, and indeed before the war, he said, the question of how to assist the development of British chemical industry by co-operation in both research and industry, and by systematic organisation in matters financial, manufacturing and educational, had been so much discussed as to weary chemists. He wished to confine himself to the synthetical chemical branch and to deal with the educational aspect, of which chemists might be most wearied. Because he was not an educationalist he was bold enough to come before them with fresh and heterodox proposals. The present situation was that many dyes and drugs, for which a demand had largely been created by Germans, had attained a position in which they had become imperative needs. The enormous rise of prices had temporarily opened the way to their manufacture over here; what was required to make that branch flourish and expand? The manufacture of synthetic chemicals was peculiar in one respect. A great diversity of operations involving expert knowledge had to be carried out in the preparation of a compound the demand for which was so small that the manufacture could not continue all the year round; for economic reasons different compounds had to be made at different times. That diversity rendered co-operation between manufacturers necessary, so that intermediate products of more general demand could be made on a large scale. Mr. Carr, however, wished to focus attention on the training of the men to carry on and to direct such manufacture.

The works chemist did not enjoy the standing of the medical practitioner or civil engineer, though his education should at least be equally lengthy. The industry required men of ability, character and courage, and their position should be improved. It was anomalous and unfortunate for technical progress that the earning capacity of the man on the technical side was inferior to that of the man on the commercial side. Partial payments by results should be more general; it had worked well for employer and employed on the Continent. That the chemist should be trained both in college and factory they all agreed. But how? To answer that question they had to discriminate between two classes of workers: (1) technically and scientifically trained departmental managers, and (2) expert operatives. The men of the first class had actually to direct the operatives' class on the spot, to tell them what to do when a reaction went wrong. To harvest from daily observations accumulative experience of practical detail was the secret of success, of high yields, diminished labour and discoveries. The manager required engineering as well as chemical training, and, further, intelligence and initiative in a wider sense than the research chemist stood in need of. The industrial chemist should not starve his research instinct, but had to interest himself also in the saving of materials, fuel and labour, and that type of training our educational system seemed to lack most conspicuously. That point was fundamental to the solution of the problem.

University education had to be supplemented in some way. The graduate, including the B.Sc.Tech., generally understood even less how to apply his knowledge than his employer did how to utilise it. The chemist, in his caged laboratory, was held at arm's length from manufacturing operations, and his lack of self-confidence increased his difficulties. The foreman's rule-of-thumb knowledge—to which great respect was due—was regarded by the manager as a bulwark not to be shaken by any theoretical considerations, however plausibly put forward by the chemist, and experience often justified that, because the first failure of the chemist was considered proof of incapacity instead of being accepted as first stepping-stone to success. The chemist must either gain knowledge by risking mistakes or remain insignificant in his laboratory. In Mr. Carr's opinion neither the research laboratory nor the industrial establishment could impart the training required to help the chemist out of this dilemma. Competitive industrial concerns certainly could not; there was the fear that the chemist should pass on secrets, real or imaginary. The chemist wanted to learn how to apply chemistry to manufacture, as the engineer had to apply physics. The history of industrial processes, the economics and the accountancy of chemistry, mathematics and engineering applied to chemistry, might be taught like electricity and electrical engineering. The scheme Mr. Carr wished to propose applied exclusively to students who had passed through a full college curriculum. It involved formation of one or more technological colleges of a new type, the college to be nothing less than a manufacturing concern, the course to extend over two years. The student would spend a considerable amount of his time in actually manufacturing those products concerning which the ordinary manufacturer had little trouble. The college would need a large permanent staff, with power of dismissing students who did not qualify in successive stages, and should insist on at least eight hours of attendance daily and short holidays. The college equipment should comprise store rooms, fitters' shops and a power plant generating steam, gas and electricity under conditions admitting of daily computation and control of efficiency, so that the student would learn to approach chemical operations quantitatively as to the value of raw materials, yield, heat and power absorbed, and time and labour expended.

Before entering into further particulars, Mr. Carr said that the institution would in exceptional cases only (*e.g.*, in brewing and tanning) be able fully to teach the methods of manufacture of particular products. In his first year the student would spend some time in the analysis of intermediate and finished products to learn the value of standards of perfection and of reputation. He would also attend courses on applied mathematics, physical chemistry, machine construction and drawing, &c., and take his turn in the workshops, in stoking, engine-driving, lead burning, &c. Lectures on steam-raising and power production would come in the second year, while the student watched and helped his seniors in manufacturing inorganic compounds, under strict discipline as regards time and quantitative results, and while he was taught how to deal with autoclaves, furnaces, compressors, vacuum pans, filter presses, &c. Arrangements should be made for the students to attend practical courses in actual works, without interference with those works. For all this it was essential that the staff should consist of men of ripened works experience, not merely laboratory experience—one of the chief difficulties of the scheme, we think, about which very little was said. As regards the substances manufactured, the student might partly be occupied in making potassium bichromate, arsenic, and hydrogen peroxide from raw materials, and partly in isolating and purifying tar products, sugars, caffeine, &c., taking up synthetic processes in the second year. The compounds manufactured would be those required chiefly by colleges and research laboratories, to be stored and sold by the college. Thus industrial efficiency would be infused, and the country be made independent, at the same time, of Germany as to pure chemicals—a subject with which Mr. Rintoul dealt afterwards. That scheme would not give serious offence in commercial quarters; for the monetary value of fine chemicals was of too little account in this country. We do not follow Mr. Carr here; for the very scheme he advocates is to alter all this, we thought. But he continued that if a manufacturer should complain against unfair competition by a privileged institution, the college would drop an article which the manufacturer supplied in adequate purity.

The long training, two or more years after taking

ELECTRICALLY-DRIVEN LATHES FOR MUNITION WORK.

CONSTRUCTED BY MESSRS. CRAVEN BROTHERS, LIMITED, ENGINEERS, MANCHESTER.

(*For Description, see Page* 378.)

Fig. 1. 16-In. Lathe for Boring Large High-Explosive Shells.

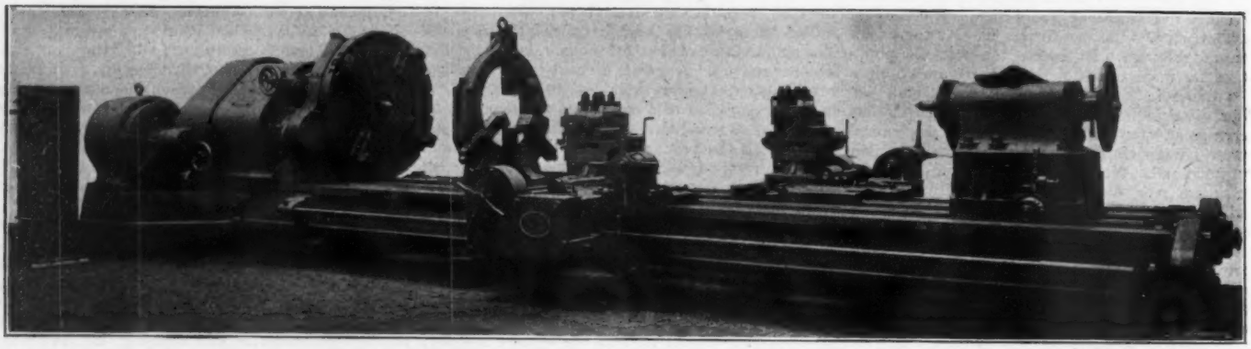


Fig. 2. 30-In. Lathe for Machining Heavy Field Howitzers.

a degree at college, would be objected to, Mr. Carr proceeded. But the training of the medical student often took a longer time, and Mr. Carr emphasised that no student in this college should proceed to his second year unless he had merited promotion, and that second year's students might receive a small remuneration. Manufacturers now paid salaries to chemists who were trying to teach themselves what this institution would teach more quickly, and there was no doubt that more money would have to be spent on the chemical industry than was spent now. The Government would have to supply the buildings and equipment, and the manufacturers to endow the institution.

Passing to the training of the expert operative, Mr. Carr considered that he would, for the present, chiefly have to be trained in the factory as before. The lack of an established apprenticeship system in chemical industry was much to be regretted. The research and analytical laboratories of works could be utilised for training selected boys from primary and secondary schools in evening classes, if the firms only engaged such boys and paid their fees. But that plan had many limitations. Our secondary-school methods often failed lamentably to produce youths suitable for industrial careers. The Board of Education did not give the schools latitude as to the particular industries of a district, and there was not sufficient differentiation at the age of 13 in the training of boys of different aptitudes. The discontinuance of the old mechanics' institutes had been a real loss; such institutes might train boys, selected on the lines on which students proceeding to the commercial course of some secondary schools were selected; the course in physics, mechanics, chemistry, mathematics, machine construction and mechanical drawing would have to extend over four years. In addition to modifying the secondary schools the Government should immediately adopt compulsory continuation of primary-school education; at least 8 hours per week should be spent until the age of 18.

As regards medicinal drugs in particular, Mr. Carr suggested that to overcome the conservatism of medical men and to help them in their difficulties as to new remedies, institutions, universities and hospitals should co-operate in performing physiological and chemical tests, and that a medical research committee should report on new drugs. He concluded by asking chemists to work out their own salvation, trusting to Government to give the needed assistance.

The Preparation of Chemicals for Laboratory Use.

Mr. W. Rintoul, F.I.C., of the Nobel Research Laboratory, Ardeer, opened his paper on "The Preparation of Chemicals for Laboratory Use" by remarking that the reagents and materials, the purity and reliability of which was so essential to their science, had in the past been obtained principally from German sources. That was not a matter for reproach. So long as their energies had had full scope in more productive fields, and so long as the supply of those bricks and mortars of chemical science had remained satisfactory, it had been economically sound to accept the position which had arisen. Of late, however, the quality of those supplies had deteriorated, while the importance of the industries involved had increased, and in the future they must in the British Empire make themselves independent of German supplies as far as possible. With one or two exceptions the raw materials for the preparation of laboratory reagents could readily be obtained in the Empire, and if the necessary knowledge and skill were made available, this growing industry need not long remain in foreign hands, so far as the requirements of this country were concerned, at any rate. Yet the difficulties to be overcome should not be minimised. In the case of an entirely new industry one was often hampered by the lack of available information and the need of investigating each step. In the case of chemicals the difficulties were of an opposite nature. An enormous literature had already grown up on the preparation and properties of the reagents; but much that was written, especially in text-books, was inaccurate, misleading and embarrassing rather than helpful; one writer copied from the other, and even when a statement was disproved it was difficult to persuade an author to take the responsibility for a corrected version. Mr. Rintoul quoted examples concerning the preparation of phthalic acid, &c.

When the preparation of reagents had been decided upon, the literature had to be studied in a discriminating spirit before a programme of experimental work for testing the methods could be drawn up. The volume of experimental and research work was such that the industry would obviously not lend itself to immediate adoption on a large scale. As every new substance taken up called for new research, a fully equipped and staffed research laboratory was required. But the need for research would fall off as the industry grew and would become spasmodic, so that periodically other work

ELECTRICALLY-DRIVEN MACHINE TOOLS FOR MUNITION WORK.

CONSTRUCTED BY MESSRS. CRAVEN BROTHERS, LIMITED, ENGINEERS, MANCHESTER.

(*For Description, see Page 378.*)

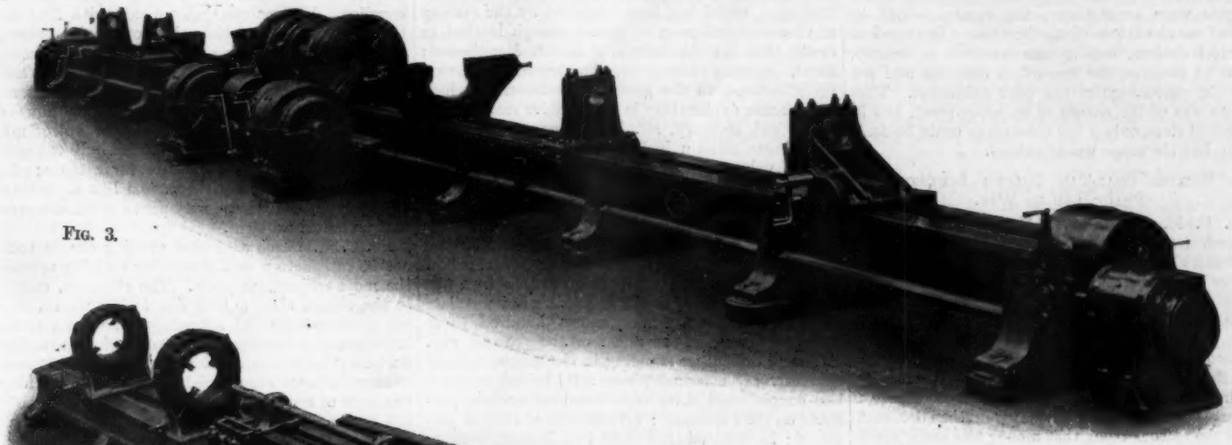


Fig. 3.

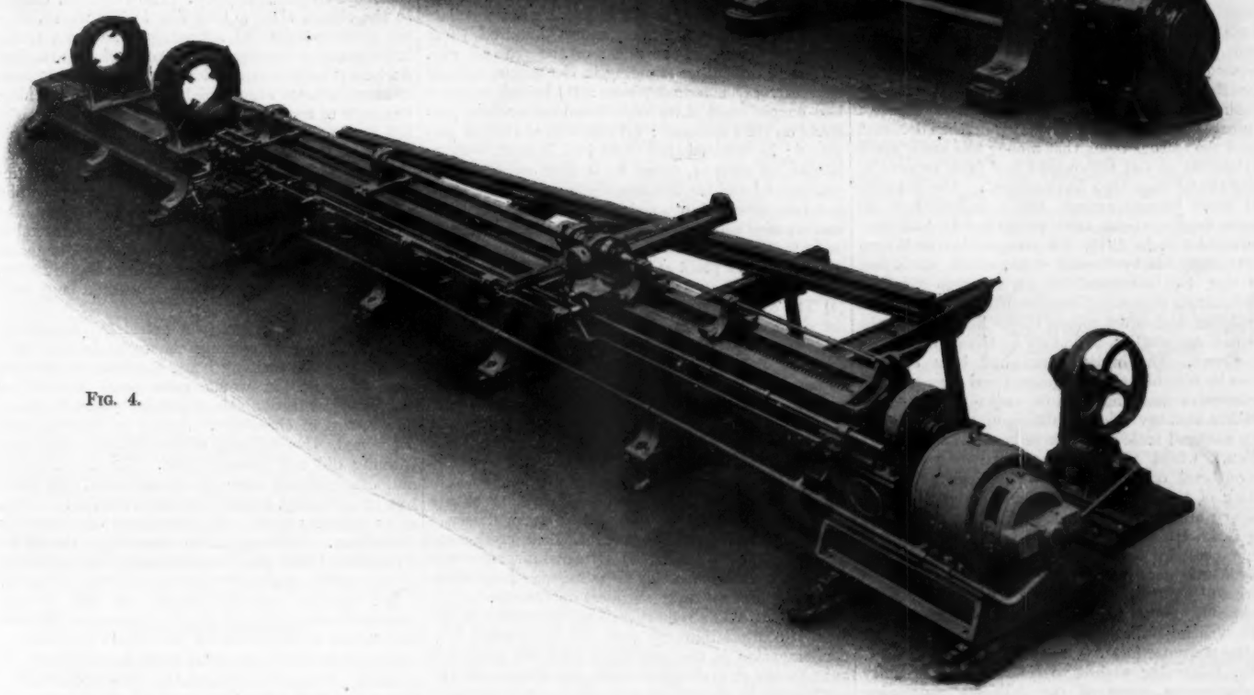


Fig. 4.

Fig. 3. Double-Ended Gun-Tube and Shaft-Boring Machine.

Fig. 4. Rifling Machine for 3-in. and 4.8-in. Guns.

would have to be found for the research staff. For this reason the preparation of pure chemicals should be undertaken under conditions which would permit of making use of some research industrial laboratory at present in existence rather than that the new industry should be saddled with the expense of a large, at times partially employed, research section. The research work required need not be confined to technical laboratories. Closer connection between university and industry was everywhere urged, though difficult and impracticable in the case of some highly-specialised processes. In the case of pure chemicals the work would be adapted to academical conditions, and the association would be beneficial to both sides, and of value as an educational implement and as means for the solution of technical problems. The work of the university would embody drawing up reports describing the best methods in detail, having in view the purity and—a point often overlooked by academical workers—the economy of the methods. At the present time the analytical knowledge and skill of the average university graduate were far from satisfactory. If some of the rather pointless communications of doubtful scientific value coming from the universities were replaced by authoritative statements on even the comparative value of methods for the preparation of important compounds, the net result would be a material gain for the country. Universities were now endeavouring to turn out graduates equipped for technical work; investigations of practical bearing were becoming more general, and if manufacturers were brought into touch with senior students they were in a better position subsequently to select chemists for their special requirements. The co-operation between university and industry would, moreover, lead to the discovery of valuable processes. That point was important also because the preparation of pure chemicals did not involve large sums nor promise large returns. Many a time a subsidiary, unlooked-for discovery had dwarfed the solution of the original problem into insignificance. In this respect some agreement would have to be arrived at as to the ownership of discoveries arising out of the study by the university of a problem suggested by an industry. With such co-operation the value of a discovery would not be lost because the inventor did not know where and how to utilise it.

As regards purity of reagents, the Institute of Chemistry and the Society of Public Analysts had last year taken a step in the right direction by issuing a pamphlet on "Reagents for Analytical Purposes." Nothing was more annoying than to find that a whole research was of doubtful value or wasted because a reagent contained an unsuspected impurity. Mr. Rintoul quoted examples, both of bad impurities and of the refinement attainable, the latter from the records of the Nobel research laboratories at Ardeer, where he is working. Some years ago certain discrepancies had been observed in their analyses and had been traced, after a rigorous investigation, to variations in the purity of the substances used for the preparation of volumetric solutions. To set this matter at rest, they decided to adopt one substance as "ultimate standard" (for their laboratory), and after consultation with the National Physical Laboratory, which had given valuable assistance, they had selected silver as the ultimate standard; as silver could not directly be used for the standardisation of acids, &c., sodium carbonate and iodine had been selected as working standards. The work had to be done with the full care of atomic weight determinations, of course, and the sodium carbonate had caused much trouble. Mr. Rintoul gave complete particulars. Taking the purity of the silver they had purified at 100, that of their iodine was 99.99 and that of their soda 99.93; their supply of these standards would last for many years.

It was now proposed, Mr. Rintoul continued, to utilise the organisation of the Ardeer laboratories for the purpose of rendering these chemicals of reliable purity available to other laboratories. During the war, however, the new department was engaged in producing certain materials wanted in small quantities for the Government. Later on they intended to supply chemicals, including, *e.g.*, the basic materials for the preparation of bacteriological stains. But purity being the main object

the operations would not be carried out on a large scale, and a special manufacturing laboratory had been equipped for this work. Each finished material, whatever its size, would be given a lot number to identify it as a unit. A sample of each lot would be analysed, as if it had come from outside; if the analysis were satisfactory, the results would be printed on the labels of the bottles to be issued to chemical dealers, and it was intended to specify, so far as possible, the impurities detected and not only the percentage of the pure substance. That scheme was of the nature of an experiment, and in the initial steps only a few substances could be dealt with; but the scope would extend.

The British Coal-Tar Colour Industry in Peace and in War.

Mr. C. M. Whittaker, B.Sc., of British Dyes, Limited, introduced his paper of the above title by remarking that the present national circumstances prevented his entering into detail which would be interesting and which would redound to the credit of British industry. He had, moreover, given technicalities in a recent paper read before the Society of Chemical Industry at Edinburgh. The British coal-tar colour industry founded by Perkin's discovery of 1856 had experienced a period of great prosperity in its early days and then declined, one of the reasons being that money was easily made in those days, and the owners had been content to enjoy the fortunes they had acquired. The industry had never become extinct, but it had sunk to its lowest depths about 1898 to 1900. It had then recovered till, in 1915, its competition had been increasingly felt by German firms, which, just before the war, had subjected British firms to a severe price-cutting campaign, because British competition in sulphur and direct cotton blacks had reduced the German conventions to nullity in those two classes of colours. The improvement had been brought about by enlightened management and a gradual and unobtrusive modernisation of works and methods. Without that revival the building-up of an industry on a national scale would have been infinitely more difficult, whilst the panic in the dyeing trade at the outbreak of the war would have jeopardised the dyeing of the clothing equipment required by the military authorities. The fact that a private firm like Read, Holliday and Sons had paid dividends of 10 per cent. for 5 years previous to the war showed that it was possible for a British firm to make a successful fight against German competition; that favourable omen was ignored by the critics, who were untiring in their gloomy forecasts of failure for the present efforts.

Mr. Whittaker wished to take this opportunity of destroying some of the fallacies concerning British firms which were still persisting in some quarters. He had for the last 15 years been in charge of the experimental dye-house of the firm mentioned, which was now absorbed in British Dyes, Limited. One of his duties was to supervise the matching of patterns sent on by customers; 50,000 patterns and samples had been passed, not a single pattern was ever charged for, and yet it had been stated during the last three months that one of the greatest mistakes of British pre-war firms had been to charge for pattern-matching whilst German firms made no such charge. They had also been accused of not issuing pattern cards and circulars, whilst they issued them in five languages and had, in 1906, already prepared manuals of dyeing instructions in three languages (including Italian and Japanese). Then British firms were charged with not sending "experts" to visit customers' houses when desired; that was wrong, though German experts were naturally more numerous than British, as their scale of operations was larger; the German expert, moreover, was welcomed, whilst the British expert was told: "We would not use your colour, if you gave it us." The British people were remarkable in depreciating the efforts of their own countrymen. It was forgotten, for instance, that the Holliday staff had introduced the hydrosulphite vat for indigo-dyeing, a French invention (Schützenberger-Lalande). Since 1901 he and his expert staff had gone out to scores of places to help over difficulties in dyeing practice, and they had quite recently been able to prove in one case that it was the water of the firm in question, and not their dyes, that had caused stains.

At the outbreak of the war the principal British firms engaged in the coal-tar colour industry had been: The British Alizarine Company (orange, red, and blue dyes principally); the Clayton Aniline Company, which had been absorbed by the Society of Chemical Industry of Basle, though located in Great Britain; Levinstein, Limited, Manchester; Read, Holliday and Sons, Huddersfield. Having again referred to the gross mis-statements, which found some explanation in the relative smallness of the British industry, Mr. Whittaker stated that in 1913 Great Britain had imported coal-tar colours to the value of 1,946,724*l.*, of which 1,800,000*l.* were estimated to have come from Germany; a large portion of these products, however, had gone farther—to India, Australia, South America and other countries. The British firms probably did not then control much more than 500,000*l.* in capital; how were they to face the competition? The task was economically and physically impossible of immediate execution in peace times, and a hundred times more impossible in the midst of the greatest war. The chief difficulties standing in the way of a rapid expansion of the industry were: (1) British industry had bought most of its important intermediate products on the Continent; (2) shortage of trained *personnel*; he doubted that there had, in 1914, been 20 British chemists of actual up-to-date experience in commercial coal-tar dye manufactures; some of these had been diverted into making explosives, and there was no reservoir of trained *personnel* from which to draw; (3) the expansion of the works demanded manufacture of plant requiring copper and lead (two war materials), and the general shortage of labour. (4) The enormous demand for high explosives, which relied on the same raw materials as dyes, sulphuric acid and nitric acid, and also benzene and toluene, to which Mr. Whittaker referred under (6). (5) The demand for dyestuffs (mordant yellow, brown and green, and sulphur black) for uniforms (also Italian and Russian), methyl violet for typewriter ribbons, and soluble blue for inks, &c. In December, 1915, his own firm had supplied 145,000 lb. of dyestuffs for khaki wool; these dyestuffs, he emphasised, were quite as fast to light, wear and exposure as any German materials, and the British dyers deserved their share of credit for the excellent equipment of the British Army. (7) Dye manufacture was extremely laborious, the so-called common black being the product of 21 chemical operations.

Mr. Whittaker's remarks about the future of the British coal-tar industry were chiefly devoted to a condemnation of the pessimists who had predicted ruin to the British motor trade, had denounced the inefficiency of the British aeroplane, and prophesied at the beginning of the war disaster to the textile and dyeing trades, which were now more prosperous than ever. When he thought of the army of German research chemists he was amazed, not at the results they had attained, but that the results were not much greater. The British chemist would do equally well. But the future depended upon the good will of the consumer as well as upon the industry. If the British consumers were honest in their expressed desire not to buy German dyes again, they would find many dyes on the British lists, and those lists would grow rapidly in the future.

The discussion of these papers on the British chemical industry was adjourned till the following day, when Dr. J. E. Stead spoke first. He said that the manufacture of iron and steel was essentially a chemical industry, and in his experience of that industry the best engineers were trained in evening classes. Such classes served to select the men who were capable of better work from those who could not be trained. He did not quite agree with the suggestion of having works attached to the college, but in making that statement he assumed that the important works of the neighbourhood were open and available for educational purposes, as was the case at Sheffield. Professor O'Shea, of Sheffield, also referred to the system in use in Sheffield, where the university and the works of the district were in close connection; he added, however, that in the majority of cases the preliminary training of evening students was not sufficient to enable them to take full advantage of the teaching offered to them. Professor R. Robinson, rising next, considered that research in pure science and in applied science should be kept distinct. Whilst research in applied science was usually directed towards some definite object, the essential feature of pure research was that it could not be controlled, but must follow the direction towards which the investigator felt himself impelled. We confess that we side with Professor Henderson in considering the boundaries between research in pure and in applied chemistry as merely traditional. No fruitful research can be really uncontrolled; no investigator will find assistance or guidance unless he be able to indicate, however generally, what he is aiming at. The object may be indefinite, merely to trace the entirely unknown cause of some obscure disturbance, for instance; what appears to be a purely theoretical line of research at the time, the future may prove to be an important technical problem.

Dr. C. H. Desch said that evening classes could not be satisfactory as a means for training men for the more responsible posts. The students, coming to the classes after a long day in the works, were too tired to take full advantage. In some trades in Germany it was compulsory on employers to allow workers of certain ages to leave early in the afternoon to attend classes which finished early in the evening. Students of engineering in the Scottish universities had a great advantage in having, as a rule, served a part of their apprenticeship before entering their classes, and they were continually kept in practice by the "sandwich system," each student spending alternately six months in the college and six months in the works. If something like the apprenticeship system of the engineering profession could be introduced into chemical and metallurgical industries, the problem of technical education would be greatly simplified.

Professor Henderson (the president) considered the time taken in evening classes to be too short to allow of the training being a substitute for full-time training. It would take years in evening classes to get through the equivalent of an ordinary day course in chemistry. So far as Scotland was concerned, the difficulty of insufficient preliminary training did not present itself. The continuation and other classes were all co-ordinated, and there was no difficulty, in the Glasgow Technical College, as to insisting upon a high standard on admitting candidates. With regard to research, it should be remembered that many students were not attracted by abstract research, but cared for practical problems.

Mr. Carr, in replying, pointed out that he had proposed evening classes for the training of foremen and skilled workers, not for directors. He found it necessary to insist that there could be no promotion from the technical ranks to the scientific direction unless the men were first prepared to go away for whole-time training in a graduating course. A possible alternative to the sandwich system, which was under trial in America under the name of the "Cincinnati system," involved duplicating all positions among the technical workers, the two holders of each post spending alternating weeks in the works and in the college. Without waiting for a perfect scheme of training, he had suggested a scheme intended to meet the most urgent requirements of the organic chemical industry in this country.

Mr. Rintoul said that the practice of Nobel's works had been to take into the works selected boys from the elementary schools and to make them attend evening classes in the Glasgow Technical College. The plan proving unsatisfactory owing to the distance of the Ardeer works from Glasgow, classes were arranged in the works and staffed by skilled employees of the firm; these classes were affiliated to the Technical College. This system had now been in use for three years, and had proved most satisfactory.

(To be continued.)

SHELL AND GUN-MAKING TOOLS.

We illustrate on pages 376 and 377 a series of tools which Messrs. Craven Brothers, Limited, of the Vauxhall Works, Reddish, have supplied for heavy munitions work. The tool represented in Fig. 1 is an electrically-driven lathe with 16-in. centres, designed specially for boring out the chambers of large high-explosive shells, and capable of dealing with shells 72 in. long. The machine automatically bores the interior of the shell

to the correct profile from end to end, the boring bar being guided by a former. The drive is provided by a variable speed electric motor capable of developing 15 brake horse-power. The range of speed variation is such as to give the lathe spindle any speed between 5 and 16.6 r.p.m. A second motor of 5 brake horse-power is provided for running up and withdrawing the boring bar. Self-acting feeds of from $\frac{1}{12}$ in. to $\frac{1}{24}$ in. per revolution of the spindle are provided for. A rotary pump maintains an ample supply of lubricant. The net weight of this lathe is 10½ tons.

In Fig. 2 we reproduce a photograph of a 30-in. centre lathe, also electrically driven, which has been specially designed for machining heavy field howitzers. The lathe will admit 20 ft. between its centres and is provided with self-acting, sliding, surfacing, screw-cutting and taper turning motions. The main electric motor is of the variable-speed type and is capable of developing 25 brake horse-power. The range of spindle speeds provided for is from 1.5 to 40.5 r.p.m. The front spindle bearing is 12 in. in diameter by 8 in. long, whilst the rear bearing is 8 in. in diameter by 10 in. long. The face-plate is 5 ft. in diameter and is fitted with extra heavy adjustable jaws of steel. There are, it will be seen, two tool carriages, each of which is provided with an adjustable swing frame and sufficient change wheels for turning tapers up to 1 in 500. The weight of this lathe is 32 tons.

The machine represented in Fig. 3 is a double-ended gun tube and shaft-boring machine, having two separate driving headstocks. It can be used as two independent boring machines for short work or as one double-ended machine for long work. In the former case the two tubes may be 15 ft. long, whilst as a double-ended machine it can deal with work up to 30 ft. long. Each headstock is driven by a variable-speed motor rated at 20 brake horse-power, giving spindle speeds ranging from 4 to 36 r.p.m. The cramping and guide pedestals will take boring bars up to 4 in. in diameter, and each self-acting saddle can be rapidly shifted by an independent electric motor of 5 brake horse-power. A rotary pump is provided for supplying the lubricant. This machine weighs 27 tons.

A rifling machine for rifling guns of 3-in. to 4.8-in. bore is represented in Fig. 4. This machine is driven by Vickers' electrical equipment, operated by automatic reversing switches, which give a variable speed for cutting with a constant quick return. The machine is supplied with a ram pump, for forcing the lubricant up the bar and distributing it at the point of the cutting tool. The various angles of twist are obtained by an adjustable bar at the back of the machine, which operates a rack and pinion rotating the bar for the required twist. The principal dimensions are as follows:—Diameter of rifling bar, 2½ in.; diameter of hole in breech stay, 21 in.; length of top and bottom bed, sufficient to give a total rifling stroke to the carriage of 20 ft. The total weight of the machine is 11 tons.

THE TWIN-SCREW MOTOR-SHIP "ABELIA."

WE begin this week the publication of drawings illustrating the twin-screw motor ship built by Sir W. G. Armstrong, Whitworth and Co., Limited, at their shipyard at Walker-on-Tyne, and engined by the Wallsend Slipway and Engineering Company, Limited, for the Flower Motor Ship Company, Limited, of London, for which Sir M. Samuel and Co., Limited, are the managers. The special feature is the application of the Diesel engine for propulsion, and the elevations and sections of the main engine on Plate XXXII and on page 384, show that in the features of design there is a closer approximation to steam-engine practice than in any of the Diesel motors of which we have knowledge. This is but one more result of the long and intimate association between the builders and engineers of the ship, and especially of Mr. R. Saxton White and Edwin L. Orde of the former, and Mr. Andrew Laing of the latter. When, on the recommendation of Messrs. Flannery, Baggallay and Johnson, the consultants for the owners, it was decided to fit internal combustion engines, the aim set was to attempt as far as was possible to meet the prejudices of sea-going engineers accustomed to work steam engines by adopting all possible features of the design of the latter, and particularly by ensuring a full view of all working parts and the greatest measure of accessibility.

Thus the general framing of the engine, which is arranged in two units with two cylinders in each, as particularly well shown in Figs. 1, 3 and 4, corresponds to the framing of a steam engine, the cylinders having feet cast to the jacket and bolted to the top of box columns, which are further bolted longitudinally for stiffness. The engine thus has an openness unusual in oil motors, and the lubrication is by drip feed throughout. This type of framing, too, makes for simplicity. On the other hand the scantlings of the columns, due to the high tension load consequent upon the much higher combustion pressure within Diesel cylinders, are extremely heavy, and the engine is larger for the power generated, as can be seen from the cross-sections. For instance, with the cylinder of 17½ in. diameter and 33 in. stroke, as here adopted, the breadth of the engines at the bedplate is about 9 ft. 9 in., and the height of the engines from the bottom of the bedplate to the top of the fuel valve over 21 ft. But in cargo-ship practice especially the question of space required is negligible. The driving of the whole of the auxiliaries, such as the pumps, compressors, scavenging pumps, &c., by means of links and levers, from the crossheads of the main engines, also conform to some extent with steam practice, and make for a shorter crank shaft and decreased length of engines and engine room. There are other notable features in the details.

The engines are of the two-stroke cycle single-acting type, each set having four cylinders of 17½ in. diameter by 33-in. stroke, and when running at 120 r.p.m. each engine gives off a brake horse-power of 600, or a total of 1,200 brake horse-power for the two sets of engines. This brake horse-power corresponds to a mean effective pressure at full power on a brake horse-power basis of 64 lb. per square inch. The ratio of stroke to bore is 1.9. This relatively large stroke-bore ratio can be adopted where the scavenging of the main cylinder is of the type as with this engine, i.e., two scavenging valves in each cylinder head.

The cylinders (Fig. 3) are of tough cast-iron with separate liners spigoted into the cylinder at the top, and free to expand downwards. The space between the cylinder and the liner serves as a water jacket, and four suitable doors are provided in the cylinder for examination of the liner surfaces in contact with the cooling water. The cylinder heads are of cast-iron, water-jacketed, the divisions for the water being arranged so as to ensure a high speed of water round the valve housings and over the lower surface. This is accomplished by having the lateral web of metal running round the cylinder head, as can clearly be seen in Fig. 3. The following valves are carried in each cylinder cover:—one fuel, two scavenging air, one escape and one starting air. These valves are all placed in separate cages and housed in suitable openings in the covers. The fuel valve casing is housed in a sleeve pressed into the cylinder head. The valve cages are of cast-iron and the valves of forged steel.

The pistons (Fig. 3) are of cast-iron made in two parts, the piston head carrying the Ramsbottom rings, and the piston rod the extension piece. The piston head is attached to the piston rod by a bolted flange, the head being water-cooled. The piston extension piece, or skirt, is attached to a flange some distance down the piston rod. There are six piston rings in the top part of the piston, and two at the bottom, these latter are for oil tightness. The bottom of the liner has a tray for catching any carbon or dirty oil which may fall from the piston, preventing it from contaminating the oil for lubrication of the other working parts of the engine. The piston rods are of forged steel, 6 in. diameter, bored hollow for the passage of the cooling water for the piston head. A steel tube is placed concentrically with the hole, the cooling water being taken up the tube and returned through the annular spaces so formed. The piston rod is attached to a crosshead by a coned end and nut. The crosshead shoes or slippers are of cast steel, single guide type, and are bolted to the crosshead. The shoes are lined with white metal on the ahead and astern faces, the sides of the shoes are also lined with white metal so as to act as guides. The connecting rods are of forged steel, 6 ft. 2 in. centres, or 4½ times the crank throw, arranged with double bearings at the top end. The lower halves of these bearings are of gun-metal lined with white metal, the upper halves and keeps being of cast steel lined with white metal. The crank pin end bearings are of cast steel lined with white metal. The small diameters of the top and bottom end bolts may be remarked upon, but it should be pointed out that these have not to take any tension load in normal working. The crank shaft is of forged steel, made in two pieces, each piece having its two cranks placed opposite, the relative angle between the cranks of the two pieces being 90 deg.

The bedplates are of cast-iron, box section, with six bearings. These bearings are of cast-iron, lined with white metal and fitted with water circulation through the bottom half of the bearings. The columns (Figs. 1, 3 and 4) are also of cast-iron, box section, bolted together at the top. The back columns carry the guides for the piston rods, the guide plates being separate from and bolted to the columns, and being water-cooled (Fig. 3). The back columns have also bearings attached to carry the rocking levers for driving the scavenging air pumps and air compressors.

The fuel-injecting air compressors, two of which are provided for each engine, are driven by rocking levers from number one and number four cylinder crossheads. These are of the three-stage type, with the cylinders water-jacketed, and intercoolers are fitted after each stage of compression. These air compressors discharge the air to a spraying air bottle, the pressure in this bottle being kept at about 800 lb. per square inch. Arrangements are made so that surplus air can be passed from the fuel-injecting air bottle to the starting air bottles, and the suction to the low-pressure compressor can also be regulated by a control cock worked from the starting platform.

The scavenging air pumps, of which there are also two for each engine, are similarly driven by rocking levers from number two and number three cylinder crossheads. Each pump is double-acting and fitted with special suction and discharge valves. The air, on being discharged from the pump at a pressure of from 4 to 6 lb. per square inch, passes through coolers, and from thence to a common pipe running the full length of the engine. From this pipe branches are taken off to each scavenging air valve on the cylinder covers. The suctions to these pumps are taken from the engine-room forward ventilators.

On each engine the following pumps are also driven from the levers which drive the scavenging air pump worked by number two cylinder—one piston-cooler pump, one jacket-cooling pump, one bilge pump and one auxiliary condenser pump. From the levers worked by number three cylinder, one piston-cooling pump and one jacket-cooling pump. These pumps are all of the single-acting plunger type.

The cam shaft (Figs. 1 and 4) is driven by skew gear from the main crank shaft, and on this cam shaft are mounted for each cylinder one fuel cam and two scavenging air cams. The cam shaft is driven through a clutch having 35 deg. lost motion between ahead and astern-going faces. The reversing shaft is driven from the cam shaft through a pair of spur wheels. This shaft carries for each cylinder one ahead cam, one astern cam, and one exhaust cam, and also operates the pilot valves for either ahead or astern.

There are four oil-fuel injection pumps for each engine, driven in two pairs by an eccentric from the cam shaft. These pumps draw from the constant head tank and discharge to their respective fuel valves in the cylinder covers. There are two cylinder lubrication pumps for each engine, each pump having eight plungers. The cylinders are each lubricated at four places, two at about half-stroke and two further down. The air compressors and scavenging air pumps are lubricated by Mollerup's lubricators.

The reversing gear is on the pneumatic system and is worked through a wheel at the starting platform (Figs. 1 and 4). This wheel controls a set of cams mounted on a shaft for ahead or astern motion. The revolving of these cams brings in sequence the following operations:—first, makes all cylinders common; second, opens starting air master valve; third, admits starting air to all cylinders; fourth, admits oil fuel to two cylinders and closes off these two to starting air; and fifth, admits oil fuel to four cylinders and closes off all starting air. When the starting air is admitted through the inlet valves, either for ahead or astern, the engine drives the cam shaft through the amount of lost motion, and thus gives it the correct relative lead either for ahead or astern running.

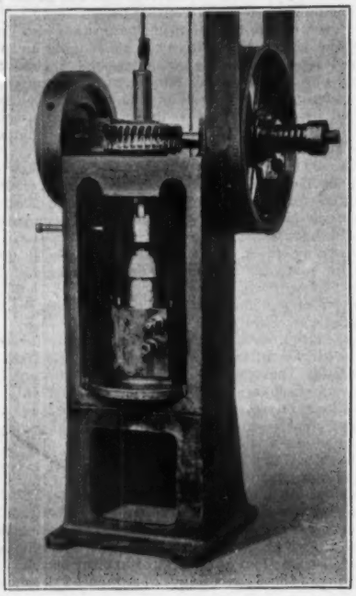
As to the water service, the jacket pumps take their water from the sea through a duplex strainer, and discharge in parallel through the air compressors, scavenging pumps, air compressor coolers and scavenging pump coolers. The discharges from these are taken into a common pipe, which is then divided up into four branches, each of which goes to the guide slipper, from there to the cylinder jacket, thence to the cylinder cover, and through the jacket of the exhaust pipe to overboard. The steam-driven ballast pump is also connected up to the jacket pump discharge pipe, so as to be able to circulate the water through the jackets before starting up the engine. The piston-cooling water pumps draw from a fresh-water tank placed in the engine room, one for each engine, and discharge through links to the hollow piston rod and from there through a cooler back to the fresh-water tanks. A by-pass is fitted between the fresh-water and salt-water pumps, both in the suction and discharge pipes, so that the pistons can be cooled with salt water if desired.

(To be continued.)

THE LATE MR. JAMES ROWE.—We regret to have to record the death, which occurred at his residence, Greenlands, Tutshill, on Tuesday, the 10th inst., of Mr. James Rowe, who from a lad until his retirement from business a few years ago had been associated with Messrs. Finch and Co.'s Works, Chepstow. Mr. Rowe was born at Buckfastleigh, Devonshire; after completing his schooling at Chepstow and at Abergavenny he was apprenticed, in 1857, to the late Mr. Finch, founder and managing director of the Bridge Works. He early showed exceptional ability both in the drawing office and in the shops; when quite young he was made assistant to Mr. Finch. On the retirement of the latter, in 1873, Mr. Rowe was appointed managing director in his stead, being then only 32 years of age. Many important engineering contracts were carried out by the firm under his direction. Mr. Rowe was not a member of any engineering institution, but his skill and ingenuity were widely recognised. He was 75 years of age at the time of his decease.

SHELL-NOSE TIGHTENING MACHINE.

We illustrate on the present page a machine which is built by Messrs. Pollock and Macnab, Ltd., Stockport, near Bredbury, to screw the loose shell-nose quite tight in position in the shell. It consists of a framework, across the top of which is fitted a worm and shaft in two bearings, one end of the shaft being provided with a belt pulley made free to rotate round the shaft, and having on its outer face a set of dogs which engage with dogs keyed to the worm-shaft. The dogs are held in contact by means of an adjustable compression spring, so that at any pre-determined pressure the dogs will be forced apart and the pulley will cease to drive the worm-shaft. The other end of the worm-shaft is fitted with a flywheel, the accumulated energy of which is sufficient to rotate the worm a revolution or



so more after the dogs have ceased to drive, thus effectively putting the final "pinch" on the nose bush.

The worm is in mesh with a worm-wheel upon a vertical fluted shaft, this shaft being free to slide up and down, but being positive in drive. The shaft is suitably balanced by means of a weight. A stop is provided as a safety provision against the fluted shaft falling down. At the lower end of the fluted shaft is fixed a suitable coupling which engages with the grip fitting; this consists of a square threaded screw having at its upper end a square shank, to which the power for screwing the nose home is applied. After tightening up, the mechanism is easily released.

The shell is gripped in a hinged fitting bolted in a cavity on the casting; this fitting consists of a body which has a vertical joint along the centre, a hinged cap being clamped up by means of eyebolts. The cap is slotted to facilitate operation.

All the working parts have ample bearing surface and are hardened where necessary.

Manchester Association of Engineers.—At the opening meeting of the session of this Association, held on Saturday last, the President, prior to the delivery of the inaugural address, presented the "Constantine" gold medal for the past session to Mr. Alfred Etchells for his paper on "Uniform Conditions for Engineering Operations and Industrial Work."

The British Fire Prevention Committee's Publications.—The British Fire Prevention Committee enters its twentieth winter session this month, and to mark the event it has issued a list of the collection of "Red Books," "Warnings," &c., that have been issued by the Committee since its formation. The list, which is obtainable upon application to the Committee's registrar at 8, Waterloo-place, London, S.W., covers the very wide field of the Committee's activities both in respect of fire protection generally and also regarding its research work. The Committee's "Red Books" number 204, and of these 35 deal with general subjects, mainly such as fire-resisting construction and notable fires. The Committee's testing operations are recorded in numerous "Red Books," grouped under such headings as Floors, Partitions, Doors and Shutters, Protection of Window Openings, Girders and Stanchion Coverings, Roofs, Textiles, Extinguishers and Sundry Fire Tests. The Committee's quarto journals generally deal with the preventive organisations of foreign countries, notably in France, Russia and Italy.

THE CORRECTION OF ECHOES AND REVERBERATION IN THE AUDITORIUM AT THE UNIVERSITY OF ILLINOIS.*

By F. R. Watson, Associate Professor of Experimental Physics at the University of Illinois, and Professor J. M. White, Supervising Architect.

I.—Introduction.

1. *Preliminary.*—The work described in this bulletin may be considered as a continuation of an earlier investigation on "Acoustics of Auditoriums." †

Figs. 1 and 2 show the floor plans of the Auditorium under investigation. The interior approximates a sphere cut off on the lower surface by the sloping floor of the room. There is a balcony, but no gallery. The balcony projects 12 ft. over the main floor at the sides and 34 ft. in the rear. The stage is built out into the room instead of being set back behind a proscenium arch as originally designed, the stage house having been omitted to reduce the cost of the building.

The domed ceiling is supported on four equal arches, and the side walls above the gallery are double curved surfaces. The limited appropriation for the building made it impossible to embellish the surfaces of the walls and ceiling, and therefore they were left practically plain, which increased their power to reflect sound and cause echoes. There are no windows in the room, the daylight lighting being exclusively through a ceiling light 30 ft. in diameter in the centre of the dome.

The results set forth in the previous bulletin are briefly as follows. A systematic investigation of the acoustical properties of the Auditorium at the University of Illinois was carried on for several years. "Cut and try" methods of cure were avoided. It was shown by theory and experiment that the usual acoustical faults in a room are due first, to a reverberation, or undue prolongation

Fig. 1. BALCONY FLOOR PLAN

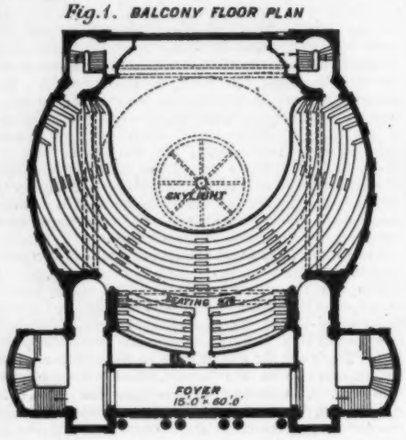
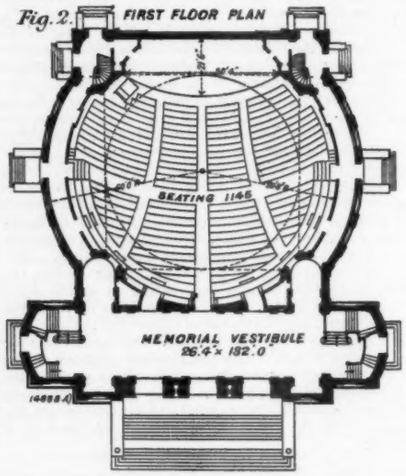


Fig. 2. FIRST FLOOR PLAN



of sound, and second, to echoes; both of these defects being caused by the reflection of sound from the walls. Various methods of cure were considered—the effect of padding and panelling the walls, the possible advantage of installing wires‡ and sounding boards,§ and, finally, the action of the ventilating system.‖ The conclusion was drawn that the most effective cure lay in padding the walls with materials which absorb sound.

An experimental diagnosis of the acoustical properties of the Auditorium was made. This was done by tracing the path pursued by a small bundle of sound when it was sent in a definite direction and noting what became of it after reflection. Several methods of tracing sound were tried before a suitable one was found. A ticking watch backed by a reflector, or a metronome enclosed in a box having a directed horn gave definite data. However, a hissing arc light with a parabolic reflector was much more satisfactory and gave conclusive results. Enough data were secured in this way to show the general behaviour of the sound in the room and also to indicate how the chief echoes were set up.¶ Attempts were then made to secure satisfactory acoustics by hanging curtains and draperies at critical points suggested by the diagnosis. This result was finally secured by suspending four large pieces of canvas in the dome.

From the acoustical standpoint the Auditorium was then in a much improved condition. The canvas, however, was very unsightly and did not accord with the architectural features of the room. It was therefore proposed that the materials used to correct the acoustics be installed in such manner as to remedy this fault. It was also proposed at this time to install a pipe organ, to decorate the interior of the room, and to change the lighting system.

2. *Object of the Bulletin.*—The object of this bulletin is to describe the changes that were made in the Auditorium to carry out the proposals just mentioned, and especially to show how the acoustical properties were modified.

II.—Preliminary Acoustical Investigation.

It was desired that the materials used to correct the acoustics be installed in such manner as to conform with the architectural features of the Auditorium. This introduced a new problem, since in the provisional cure the canvas sheets in the dome hung with very little conformity to the curvature of the walls. A further complication appeared when it was found by calculation that the amount of material necessary to correct the reverberation was insufficient to pad all the walls that produced echoes. It was desirable to eliminate the echoes, but it was regarded as risky to install too much sound-absorbing material, owing to the danger of making the Auditorium too dead for sound.

Because of these difficulties it was decided to carry on further experiments and to secure more data before deciding on the final cure. Accordingly, one large curved wall was covered with strips of 1-in. hair felt, 30 in. wide, placed vertically and 30 in. apart so as to leave bare spaces between them. This arrangement was satisfactory for several reasons; it did not change the curvature of the wall; it used only half the amount of material necessary to cover the entire wall; and because of diffraction and interference effects it was theoretically more efficient in breaking up the reflected sound than if the same material were spread continuously over the whole surface. Although encouraging, the results were not so marked as expected in diminishing the echoes.

On the basis of this experiment, plans were made for covering other walls in a similar way, except that the hair felt was to be mounted on wooden ribs built out from the wall surface. Such an installation seemed more likely to break up the incident sound than the first plan of mounting the hair felt snugly against the wall. The sound wave on striking these outer felt strips would suffer partial reflection and change of phase, while the remaining portion of the sound would pass through the open spaces and be spread out by diffraction and reflection from the walls. The hair felt strips would oppose the incident and reflected waves, thus breaking up the original sound and diminishing its intensity and possibility of producing echoes.

Because the scaffolding erected for the use of the workmen interfered with the passage of sound waves, the efficiency of this method of placing the felt could not be tested step by step as the material was mounted. The test was deferred, therefore, until the installation was completed. In the meantime the pipe organ was installed, the interior was redecorated, and the lighting system changed, so that only the combined effect of all these factors on the acoustics could be investigated.

III.—Modifications of the Interior of the Auditorium.

3. *Installation of the Pipe Organ.*—The organ was mounted in a unique way by dividing it into two parts and placing them in lofts 24 ft. above the ends of the stage with a distance of 75 ft. between centres. This arrangement placed the organ at a considerable distance above the audience. The absence of any vertical surface between the lofts and the audience room prevented any visible arrangement of the organ pipes, but the necessary free exit of the sound was provided for by the construction of ornamental plaster grilles covering the pendentives on either side of the stage.

4. *Method of Mounting Hair Felt.*—The hair felt was mounted on thin furring strips, which were bent to fit the curvature of the surfaces. The dome above the arches and the double curved side walls and single curved rear wall above the balcony were padded in this way. The felt was mounted in vertical strips on the west side wall.

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* From Bulletin No. 87 of the Engineering Experiment Station, University of Illinois.

† Bulletin No. 73 of the Engineering Experiment Station, University of Illinois.

‡ "Inefficiency of Wires as a Means of Curing Defective Acoustics of Auditoriums." *Science*, vol. xxxv, page 833, 1912.

§ "The Use of Sounding Boards in an Auditorium." *Physical Review*, vol. i (2), page 241, 1913. Also *The Brick Builder*, June, 1913.

‖ "Air Currents and Acoustics of Auditoriums." *Engineering Record*, vol. lxvii, page 265, 1913.

¶ "Echoes in an Auditorium." *Physical Review*, vol. xxxii, page 231, 1911.

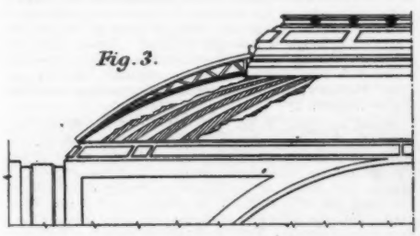
On the east balcony wall the felt was mounted on wooden ribs so that it stood concentric with the plaster surface at a distance of one foot. Eighteen inches below the edge of the skylight in the dome radial strips of felt, which approached the wall until they touched at the crown of the arches, were mounted on wooden ribs. (Figs. 3 and 4.) The hair felt used was the Akustikos Felt developed especially for correction of acoustical faults by the H. W. Johns-Manville Company under the direction of Professor Sabine.

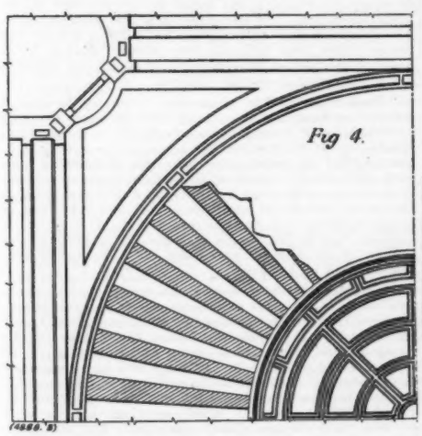
Before the changes were made in the Auditorium, Professor Sabine visited the building at the invitation of President James. After this visit, he wrote to President James as follows: "If such confirmation of the results of Professor Watson's investigation is necessary, please permit me to assure you that you will obtain an excellent effect from following out his suggestions in all detail." The final installation was modified somewhat from the original plans, but the general features were maintained.

5. *The Decoration and the Lighting System.*—The modification of the lighting system involved the elimination of the suspended fixtures. The wall brackets were retained, but the main lighting was changed to a semi-indirect system with reflectors above the arches and around the skylight. An ivory tone was selected for the basic colour in the redecoration. Ornamentation was stencilled and painted on the various walls and surfaces to give a unified effect. With the exception of the ornamental borders the rep covering the padded surfaces was left its natural colour. The modifications relieved the auditorium of its cheerless, barn-like interior.

IV.—Final Acoustical Investigation.

The remodelled Auditorium has been tested under varied conditions for music and speaking, and popular opinion has pronounced the acoustics satisfactory. A





speaker with a moderate voice can be heard distinctly by auditors in the most distant seats. The music of the new pipe organ, according to experts, is satisfactorily rendered. The room is also suited for orchestra music, though for this case it has been found advantageous to follow the usual custom of leaving the wooden floor of the stage bare of carpet, so as to reinforce the sound from the instruments.

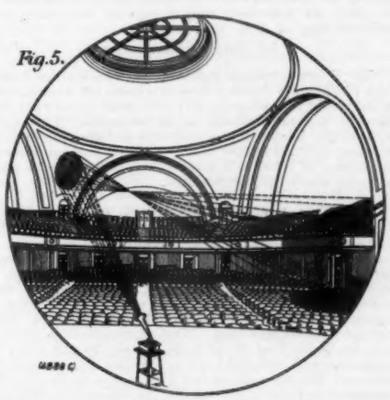
While the Auditorium has proved to be generally satisfactory, a detailed investigation of the acoustical effects secured by the modification of the room was thought desirable. A request was made, accordingly, that auditors report any echoes or acoustical disturbances, however slight they might be. About a dozen replies were received, and on the basis of these and other considerations a systematic investigation was undertaken.

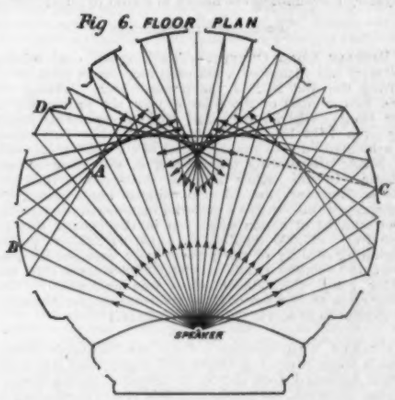
The acoustical results, beneficial and otherwise, may be anticipated by considering the changes made. According to Sabine, the hair felt installed would reduce the reverberation. This would also eliminate echoes if installed on certain surfaces in accordance with the analysis; but, since the amount of material used to correct the reverberation was insufficient to cover all the walls, acoustical defects might still be set up by the unpadded surfaces, especially by the pendentives. The pipe organ, by generating musical sounds that emerged through the pendentives in the dome, might introduce new acoustical disturbances. The openings made in the surfaces of two of the pendentives for the passage of the organ music would reduce the general reverberation and would also diminish echoes. The changes in the decoration and in the lighting system would produce little effect.

6. *Investigation of Echoes.*—Tests were made in several ways to determine the presence of echoes. The opinion offered by auditors that the echoes had generally disappeared was, of course, the most satisfactory evidence. One test was made by talking through a megaphone toward different walls. The sound was generated inside a small house and its direction of propagation controlled by two megaphones, one being pointed toward an observer and the other toward a wall which previously gave echoes. No distinct echo could be obtained by speaking simultaneously into the two megaphones. The ticks of a metronome produced very little additional effect, but when a sharp intense metallic sound was tried, echoes were obtained from the unpadded walls, but only faint responses from the padded walls. The intense hissing sound of an arc light backed by a parabolic reflector gave more pronounced results. It showed that the padded walls produced a marked effect in reducing the intensity of the sound.

The effect of the unpadded pendentives in the rear dome surface is shown in Fig. 5. The cone of incident sound received by each pendentive is small and, after reflection, spreads over a large area. It was therefore anticipated that little disturbance would result. This prediction was not entirely correct since the echoes reported by auditors, so far as could be ascertained, came from these two walls. An echo was perceptible when the speaker faced directly toward one of these pendentives so that the profile of his face was seen by an auditor seated at one side of the auditorium. The direct sound coming to the auditor was then diminished, while the reflected sound was augmented, thus producing an echo.

Other unpadded walls, notably the side walls under the balcony, still set up concentrations of sound. Thus an observer at A, Fig. 6, can hear not only the direct sound from the speaker, but also the portion that is concentrated by reflection from B. He does not hear an echo, because the time interval between the direct and reflected sounds is too short to enable his ear to detect them separately. The result is much the same as if his neighbour on the side toward the wall were to say the words of the speaker in his ear at the same time that he received them from the speaker. The auditor realises that something is peculiar about the sound, but usually does not understand the cause of the trouble. An auditor at C, however, may get an echo when the speaker faces the point D.





7. *Investigation of the Reverberation.*—By means of Sabine's formula and coefficients of absorption* the time of reverberation of the Auditorium was found and a calculation was made to determine the amount of sound-absorbing material necessary to correct the fault. The following tabulation shows the method employed:—

Material.	Exposed Area in Square Metres.	Coefficient of Absorption.	Total Absorption.
Plaster on lath ...	2000	0.0330	66.0
Plaster on tile ...	510	0.0250	13.0
Woodwork	1630	0.0610	99.0
Glass	83	0.0270	2.2
Cocoa matting ...	145	0.0200	2.9
Wood seats	2150 seats	0.0082	17.7
			201
Average audience ...	1200 people	0.44	527
Total	—	—	728
Volume of room ...	12,000 cub. m.		

Substituting these data in the formula $t = 0.164\ V \div a$, in which t is the time of reverberation, V the volume of the room and a the total absorbing power, the following equation for the empty room is obtained:—

$$t = 0.164 \times 12000 \div 201 = 9.8 \text{ seconds.}$$

When an audience of 1,200 people is present.

$$t = 0.164 \times 12000 \div 728 = 2.7 \text{ seconds.}$$

This value is too great for good acoustics, and a reverberation results. To correct the fault, absorbing material should be added until the time of reverberation is reduced to about 1.8 seconds; this value having been found satisfactory for halls as large as the Auditorium when used for both music and speaking.

The amount of Akustikos Felt needed to carry out the plans already described was 3,315 sq. ft. This was less than the area necessary for felt mounted snug against the wall, since the coefficient of absorption is greater when the felt is mounted out from the wall.* Calculations, which allowed for the sound-absorbing power of the felt and the other alterations in the Auditorium, indicated that the time of reverberation would be reduced to about 1.90 seconds with 1,200 people present.

V.—Discussion and Conclusions.

The Auditorium fulfilled the theory held many years ago by Lord Rayleigh† that a large room with hard, non-porous walls and with few windows has a prolonged resonance, and that the best chance of improvement lies in padding the walls and ceiling with sound-absorbing materials. Thus the installation of hair felt in the Auditorium reduced the reverberation; the amount of reduction being calculated in advance by Sabine's‡ formula and constants of absorption.

The amount of hair felt necessary to correct the reverberation was insufficient to cover all the walls, and it was found that some of these unpadded surfaces still produced echoes. This action was anticipated in part from the general considerations discussed by Rayleigh,§ in which the possibility of reflection of sound was shown to depend on the positions of the source and receiver of sound, and also upon the size and form of the wall compared with the wave length of the incident sound.

The installation in an auditorium of considerable sound-absorbing material eliminates the objectionable condition of satisfactory reverberation being wholly dependent on the sound absorbing power furnished by an audience. This means that rehearsals without an audience can be conducted satisfactorily, and that a speaker addressing a small audience is not obliged to contend with a distressing reverberation.

The theoretical advantages in absorbing and breaking up sound waves when hair felt is mounted out from a wall instead of placed snugly against the surface do not appear to be so great as expected. Observers listened to sounds reflected from both types of surface, and concluded that a surface having the hair felt mounted out from the wall was more efficient. The conclusions, however, should be checked by quantitative, instrumental measurements, since the ear is inaccurate in its estimation of the comparative intensities of different sounds.‖ It appears that the felt is more effective when mounted out from the wall, but there is some question whether or not the advantages secured justify the additional expense of installation and the greater risk of fire.

The music of the pipe organ emerging in large volume from the pendentives in the dome introduced concentrations of sound different from those set up when the source of sound was on the stage. This made it desirable to pad other walls in addition to those requiring padding for the single source of sound.

The effect of the organ music confirmed one conclusion set forth by Jäger,¶ namely, that the strength of the source of sound, for good acoustics, should be in correct proportion to the volume of the room. It appears that the Auditorium is too small for loud organ music, since the sound in this case becomes unpleasantly intense. On the other hand, it appears that the volume is fairly well suited for softer organ music and for a weak source of sound, such as a speaker with a moderate voice. In this connection Jäger contends that an auditorium is limited in its acoustical possibilities; that if a room is too large, it is impossible to make it satisfactory for weak sources of sound. He points out also that the problem of correcting faulty acoustics must include a consideration of intensity of sound as well as of reverberation; that is, the variable factors at command, the volume and absorbing power of the room and the source

* *American Architect*, 1900.

* Sabine. Architectural Quarterly of Harvard University, p. 22, March, 1912.

† *Theory of Sound*, vol. ii, pages 287 and 351.

‡ *American Architect*, 1900.

§ *Theory of Sound*, vol. ii, page 283.

‖ Rayleigh, Scientific Papers, vol. ii., p. 132.

¶ "Zur Theorie des Nachhals," Sitzungsberichten der Kaiserl. Akademie der Wissenschaften in Wien. Mathematurw. Klasse; Bd. CXX, Abt. IIa, Mai, 1911.

of sound, must be so proportioned as to give not only a suitable reverberation, but also an acceptable intensity of sound. He discusses the limitations in obtaining this desired result.

Another deduction made by Jäger which applies rather directly to the Auditorium is that the ratio S/w should be large for good acoustics, in which S is the total surface of walls, furniture, and fixtures struck by the sound and w is the volume of the interior. Theoretically, this ratio is smallest for a sphere, and, since the Auditorium approximates a hemisphere, the excessive reverberation might have been predicted.

Reverberations and echoes were corrected simultaneously by installing a suitable amount of hair felt on the walls which produced echoes. To locate these walls, a new method was developed in which the source of sound was an arc light, as explained earlier in this bulletin.

The investigation showed that curved walls are worse acoustically than plane walls, since they produce undesirable concentrations of sound and echoes. It also appears that the openings in the pendentives for the organ music and the ventilation openings act similarly to open windows, and thus reduce reverberation and diminish echoes.

One acoustical disturbance which was not corrected was that due to talking and walking in the foyer and on the stairs immediately outside the Auditorium. The sounds of footsteps and the reverberation caused by loud talking and accidental noises in the foyer could be reduced by covering the stairs and foyer with a yielding material, such as cork, and by padding some of the walls.

It is apparent from this discussion that the means employed to correct the acoustics, as exemplified by this complex problem, were based upon established scientific principles, and this investigation and others of like nature have served, to a large extent, to dispel the mystery surrounding the action of sound in auditoriums.

Russian Coal Output.—The Russian coal mining industry has witnessed a material increase in production during the first half of the present year. During the first five months of the present year the production of the Donetz district exceeded the corresponding figure for even 1914 by some 50,000,000 poods. This result is principally due to the enterprise of the mining concerns in better distributing labour and in importing foreign labour. In the other Russian coal-mining districts, which, however, are of subordinate importance, the present year also shows a material increase in production. The number of hands employed in the Donetz district rose from 165,000 on July 1, 1915, to 222,000 in the beginning of July of the present year, and output rose from 790,000,000 poods to 856,000,000 poods; of the latter total 177,000,000 poods was anthracite. The proportion of 30.8 per cent. of the total output remained at the mines as stock. (1 pood = 36 lb.)

German War Profits.—Both the Bismarck Hütte, with a share capital of 16,000,000 marks, and the much larger Aumetz-Friede Hütte, in Lorraine, having a share capital of 58,000,000 marks and debentures amounting to 33,100,000 marks, have done exceedingly well during the year 1915–16, the latter paying 10 per cent. dividend, against no dividend for the two preceding years, and the former 25 per cent., against 15 per cent. for last year and no dividend for several preceding years. The Bismarck Hütte has a total net profit of 5,354,261 marks for 1915–16, against 3,580,161 marks for the preceding year; the writings-off amounted to 4,870,037 marks, whilst 1,230,000 marks were added to the invalid and pension fund. The report of the Aumetz-Friede concern states that in spite of difficulties it has been possible to increase the output of the iron mines and blast-furnaces, steel works and rolling mills. The Steel Union and Pig-Iron Union not only afforded ample opportunities for sales but also had orders which, notwithstanding every effort, it was impossible to carry out. The earnings of the works, it is added, were much affected by the high and ever-increasing cost of production. The net profit of the Aumetz-Friede concern reached a total of 7,515,610 marks, against 999,254 marks for the preceding year, writings-off amounting to 6,580,367 marks. The production of coal had been 18 per cent. higher than during the preceding year, and amounted to fully 80 per cent. of the peace production. The aggregate production of coal, including that of the concerns connected with Aumetz-Friede, amounted to 1,562,620 tons, that of coke to 760,299 tons, the production of iron ore being 1,335,416 tons, of pig-iron 533,344 tons, and of steel 452,918 tons. The hands employed numbered 14,495. The Mannstaldt rolling mills, connected with the Aumetz-Friede concern, after very liberal writings-off, show a total net profit of 1,131,752 marks, against 114,205 marks for the previous year; a dividend of 8 per cent. was paid on the whole capital in addition to 6 per cent. on the preference shares to compensate for the preceding year, when they received no dividend. Another allied concern, the Düsseldorf Iron and Wire Company, had a net profit of 608,894 marks, against 26,388 marks for the preceding year, and a dividend of 7½ per cent. was declared. The Hasper Iron and Steel Works earned for the year 1915–16 6,805,500 marks, against 2,127,600 marks for the preceding year; the dividend paid was 16 per cent. (against 4 per cent. for the year before), the war profit tax and other funds having been amply provided for. The Hirsch-Janke Glass Company, Weisswasser, had a surplus of 423,410 marks for last year, against 78,463 marks for the previous year, and paid 20 per cent., against 4 per cent. The Magdeburg Machine Tool Company, formed in 1915, paid 15 per cent. for that year, and is increasing its capital from 1,300,000 marks to 3,000,000 marks.

NOTES FROM THE UNITED STATES.

Philadelphia, October 4, 1916.

Underlying conditions in the steel industry remain in the same overstrained condition. In view of the heavy contracts coming in and in sight an active pig-iron market has set in, resulting in an advance over recent quotations of from 50 cents to 1 dol. per ton. Sales in this district for a week foot up over 150,000 tons, and other districts show corresponding activity. An increase of 2 dols. per ton in structural material has not checked buying to any extent. The demand is of an overwhelming nature. The contemplated industrial rejuvenation of Russia and the undertaking of vast railroad construction in China is leading the steel industry here to regard an enormous expansion of capacity as safe and logical. With the steel industry sold up practically for six months of next year it is apparent that prices will further advance. It is the general belief that still further advances will be made in pig-iron, and one Eastern concern has just closed for 60,000 tons of basic. The Russian inquiry for 30,000 cars is still hanging fire, and it is believed that the Pressed Steel Car Company will undertake to divide the order among a number of lesser makers. Russia is in the market to-day for 75,000 tons of barbed wire, and that Government is in a hurry for it. The placing of this large order will probably be followed by a further advance of 2 dols. per ton. Phosphorus iron has advanced 1 dol. a ton, and one concern has an order for 30,000 tons for next year's delivery, Steel shares are reaching wild prices in the stock markets. Quotations on common stocks will soon double the original value. Speculation is running wild on all well-known steel stocks, notwithstanding the enormous extension in capacity which is becoming available. At the present rate of pig-iron buying the blast furnaces will soon be out of the market for some six months if they accept all the orders that are crowding in.

The United States Railways.—The United States, says *The Marine Journal*, not only leads all other nations in the world in possessing 257,569 miles of railways, but exceeds Europe's mileage by 50,000 miles. The equipment of the United States railways includes 65,000 locomotives and 2,327,000 cars. The average number of employees is 1,409,342, and the total wage paid them last year was 1,165,000,000 dols.

Our Rails Abroad.—The exports of rails from the United Kingdom appear to be shrinking more and more. In September they only amounted to 2,712 tons, as compared with 15,800 tons, and 39,185 tons. No rails were forwarded to Australia in September, although in September, 1914, we despatched 12,085 tons to that quarter. The exports to India sunk to 201 tons in September this year, while in September, 1914, they amounted to 18,894 tons. The aggregate shipments of rails to September 30 this year were 36,458 tons, as compared with 205,952 tons in the first nine months of 1915 and 365,939 tons in the first nine months of 1914. Argentina only took 109 tons of British rails to September 30 this year, while in the first nine months of 1915 Argentina imports amounted to 24,927 tons. The colonial demand moved on as follows in the first nine months of the last three years:—

Colonial Group.	1916.	1915.	1914.
	£	£	£
South Africa	339	331,980	47,564
British India	17,888	37,714	133,342
Australia	928	58,913	107,115
New Zealand	629	17,180	15,259
Canada	2	9	122

The variations are on account of the war. The value of the rails exported to September 30 this year was 386,487*l.*, as compared with 1,495,511*l.* and 2,445,837*l.*

The Bank of Electrical Undertakings.—The Bank of Electrical Undertakings at Zurich has a share capital of 75,000,000 francs and debentures to the value of 84,900,000 francs. It is interested in electrical undertakings, having 139,580,000 francs in shares, &c., in addition to advances amounting to 34,880,000 francs. The electricity works have, as a rule, had to face an increased expenditure in fuel. On the other hand, the traffic on the different tramway concerns is getting more active and the fares show a tendency to rise. The undertakings in which the bank is interested have suffered no loss from the war, but the unfavourable rates of exchange have caused a serious loss, and the revenue has receded 661,000 francs. The net proceeds, however, were barely 200,000 francs below those of the previous year, the figures being respectively 6,064,587 francs and 6,249,877 francs. The dividend was again fixed at 8 per cent., against 10 per cent. for the year preceding the war. The bank is interested in more than a dozen electrical undertakings, electric power stations, some tramway companies, the largest item being 26,280,000 marks in the Lahmeyer Electric Company of Frankfurt. Of other concerns may be mentioned the German Overseas Electric Company, 4,980,000 marks, and, altogether, German concerns seem to be in the majority; also some Italian, Spanish, Russian, Roumanian, Turkish, &c. Most of the undertakings have paid about the same dividends as during the preceding year, but as to the Abo Electric Works, Finland, a German concern, no news has been received since the war broke out, and the Upper Rhine power station at Mülhausen, Alsace, has suffered from the proximity of the war and again declared no dividend. The Moscow Company for Electric Power Transmission paid no dividend, the same applying to several other concerns. The Bavarian Nitrogen Company was expected to pay at least 12 per cent.

NOTES FROM THE NORTH.

Glasgow, Wednesday.

Glasgow Pig-Iron Market.—The pig-iron warrant market remains in the same lifeless condition which has characterised it for some time now, nor is any change yet apparent. Stocks in public store show little difference during the week.

Scotch Steel Trade.—No possible estimate could be made of the amount of work being put through in the steelmaking establishments in the West of Scotland, most of which are running constantly day and night. And still the necessity for endeavouring to increase the output is kept well in front of the makers by those in authority. Considerable demand exists for ordinary structural lines, but makers are finding much difficulty in meeting this demand, chiefly owing to the obstacles, shipping and otherwise, preventing good and regular deliveries of the required raw material. Export inquiries are steadily on the increase, but here also difficulties stand in the way—licences being granted but sparingly. These facts would almost suggest a possible firming up of prices which, however, are practically unchanged over the week. Steel ship plates are still quoted about 14*l.* per ton; boiler plates, 15*l.* 5*s.* or a trifle more; and angles, 14*l.* 7*s.* 6*d.* or thereabouts.

Malleable Iron Trade.—There is no lack of business in the malleable iron trade, order books being so well filled up that makers continue to find difficulty in supplying the demands on their customers. This, of course, means constant activity for some considerable time to come. While a small export business is being done in iron bars, the bulk of the output is being absorbed by home consumption, both for Government contracts and private mercantile trade, the iron and steel departments being alike fully employed. Indeed, quite a considerable amount of ordinary mercantile business is now being put through even for export, the restriction barriers notwithstanding. Prices are well maintained, with a tendency towards a slight advance, "Crown" bars meantime being quoted 14*l.* 10*s.* net f.o.b. Glasgow, named brands commanding a rather higher figure.

Scotch Pig-Iron Trade.—The demand for Scotch pig-iron of all grades, and particularly for hematite, continues unabated, and there seems faint prospect of any change in the immediate future. Production goes on apace, and little or no stock is being accumulated. Licences are still difficult to procure, very few being permitted, the effect of this reacting upon business in a very special degree. The ban upon the export of hematite is especially rigorous, so much being required in the home steelworks, the demands of which are insatiable. No alteration has taken place in current prices, the present firm level keeping very steady, due in great measure to the high rates now asked for all raw material and the increasing on-cost charges.

"Trade After the War" Committee.—Among the various reports received by the Committee presided over by Lord Balfour of Burleigh, that presented by the Scottish Ironfounders' Federation has been so favourably considered that two representatives of the Federation were invited to attend a meeting of the Committee in support of the views expressed in the report. The subject of the future industrial conditions of the country are of national importance, and the report of the Scottish Steelmakers' Association, which is at present in preparation, will be of considerable value also, as many useful suggestions will be available.

Wages in the Clyde District.—A few days ago there was issued to the joint secretaries of the Scottish Manufactured Iron Trade Conciliation and Arbitration Board an intimation signed by Mr. John M. Macleod, C.A., Glasgow, regarding makers' profits during the months of July and August. Mr. Macleod says: "I have examined the employers' books for July and August, 1916, and I certify the average net selling price brought out is 13*l.* 2*s.* 8.29*d.* per ton. This means an increase of 5 per cent. in the wages of the workmen." The statement is more satisfactory than is that indicating that nothing has yet come of a conference held recently between representatives of the blast-furnacemen employed in the Glasgow district and their employers, for the purpose of adjusting the rates of wages and week-end allowances.

German Activity in China.—It seems strange that just now, while the trouble is going on in Canton, the Germans in Shameen, living on the British Concession and having their offices and godowns there, should be coining money by storing goods for the Chinese, says a Hong Kong paper, to which *The London and China Telegraph* refers. Most of the German firms were before this simply "carrying on" by doing a little business with the Chinese and getting rid of old stocks. As a result, most of their godowns and stores were empty, and they were in a peculiarly fortunate position when the Chinese started rushing their valuables across the British Bridge. They have been able to get better prices this time than have ever before been got for storage, and they are coining money. This will enable them to carry on for a long time and, perhaps, to keep their offices in order ready for the time when peace is restored in Europe. They are in better spirits on this account, and they do not care how long the present Canton situation lasts. The German flag is to be met with everywhere. Over the cement works on the river opposite Tai Sha Tou a huge German flag is flying, and in the western suburbs, where some of the Germans have their offices, German flags are quite common. The consulate on Shameen and some of the hongs, &c., are flying their flag—indeed, it seems a misnomer to call this the British Concession.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—The activity of the past few weeks is maintained in all departments. Hard steams are firm, and full deliveries are being secured by industrial concerns and railway undertakings. There is also a large demand for cobbles and nuts. In many cases works are getting sufficient surplus over daily requirements to complete their stocks. Gas producers are asking for full supplies, and heavy tonnage is going into inland works on contract account. The freer deliveries from the pits have increased the volume of business on the open market, both for home and export trade, and except in the case of France and Italy, who are the principal customers, export prices are slightly increased. House coal continues to meet a brisk inquiry. Quotations:—Best branch hand-picked, 20*s.* 6*d.* to 21*s.* 6*d.*; Barnsley best Silkstone, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire best brights, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire house, 17*s.* to 18*s.*; best large nuts, 16*s.* 6*d.* to 17*s.* 6*d.*; small nuts, 15*s.* 6*d.* to 16*s.* 6*d.*; Yorkshire hards, 16*s.* 6*d.* to 17*s.* 6*d.*; Derbyshire hards, 16*s.* to 17*s.*; best slacks, 12*s.* to 13*s.*; seconds, 10*s.* 6*d.* to 11*s.* 6*d.*; smalls, 8*s.* to 9*s.* per ton.

Iron and Steel.—The material market has a firm tone, and several heavy transactions for common irons have just been completed, the prices paid being according to the Government scale. Basic iron is now much more easily obtained, whilst steel billets are to be had in good parcels for all classes of work of national importance. For other work, such as the "domestic" trade, it is not so easy to secure the necessary certificates to purchase materials, the authorities urging the vital requirements of other manufacturers more directly concerned with the war than that of furnishing the "silver bullets." Even so, there are manufacturers who declare there are ample supplies, and any scarcity is artificial. Full pressure is maintained upon all works, especially in the finished trades. Revised opinions of the value of Sunday labour, based upon prolonged practical experience, are increasingly growing in favour of abolition of the practice, except in so far as it is necessary in emergencies. It is felt that a regular six day week would be more productive than the present system. No definite action, however, has yet been decided upon. Another delicate subject is the one of debadging. The new order is that all unskilled men under the age of 30 must be released for military service, and labour still further diluted. It is a vexed topic, especially as the present supply of able-bodied labour has been considered inadequate. The Ministry of Munitions is fully cognisant of the whole situation, and no injustice will be knowingly done to important Sheffield industries. Several of the minor departments of trade are showing a welcome revival of prosperity. In the light castings trade the demand for gas heating and cooking apparatus, following the desire for fuel economy, is filling up the gaps created by the depression in the builders' iron foundry work. Agricultural machinery and plant makers are doing a large export business, and the Argentine Republic contains some of their best customers. The file and saw manufacturers are assured of full order books for months ahead. Cutlery concerns are working at full pressure. From overseas, orders have arrived for tools, saws, springs, cutlery, hardware, printing plant, vices, axes, and electro-plate.

Sheffield Trade Matters.—Presiding at the annual meeting of Messrs. Kayser, Ellison and Co., Limited, on Monday evening, Mr. C. W. Kayser observed that the record of the year's workings was one of great pressure and of great success. The balance, after allowing for war taxation, &c., was 45,811*l.* 13*s.* 5*d.* They were carrying 10,000*l.* to the depreciation fund owing to the exceptional wear and tear caused by the war upon the machinery, and they were placing 5,000*l.* to an employees' benefit fund to help them to overcome the physical strain the arduous war conditions imposed upon them. The works had been kept running day and night. The firm's stocks in Russia and other Allied countries had been very keenly sought after, and the result was their stocks were reduced and their cash at bank appreciably increased. The dividend was at the rate of 12½ per cent. for the year, plus a bonus of 7*s.* 6*d.* per share, all free of tax. In the preceding two years the dividend was 15 per cent., and in 1912–13, 20 per cent. Messrs. A. J. Halcomb and B. C. Davis were re-elected directors.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—The pig-iron market presents very few new features of moment. Good enquiries for Cleveland pig are reported, and a moderate amount of business is passing. Forge quality is plentiful and is offered rather freely, with the result that purchases can be made at a little below recognised market quotations. For home consumption, No. 3 Cleveland pig, No. 4 foundry and No. 4 forge all stand at 87*l.* 6*s.*; and No. 1 is put at 91*s.* 6*d.* There is a pressing demand for export, and buyers are prepared to pay 100*s.* for warrant iron. Holders of warrants, however, are in no hurry to accept that figure. Makers' No. 3 is quoted 98*s.* to 100*s.* for shipment abroad, and No. 1 ranges from 102*s.* 6*d.* to 105*s.*; whilst No. 4 foundry is put at 96*s.* 6*d.* and No. 4 forge at 95*s.* 6*d.*

Hematite Iron.—There is little new to report concerning the East Coast hematite branch of the staple industry. Heavy deliveries are being made on running contracts, but very few sales are occurring, due to the fact that producers are well sold to the end of the year, and are not at present inclined to commit themselves further ahead. Nos. 1, 2, and 3 remain at 122*s.* 6*d.* for home use and for shipment to France, and 140*s.* and upward for general export.

Output of Pig-Iron.—A second furnace has been put into operation at the Redcar Ironworks to manufacture hematite iron, making the total number of furnaces blowing on the North East coast 72, of which 28 are making Cleveland pig, 31 are turning out hematite, and 13 are producing special kinds of iron. Other idle furnaces may be re-started at an early date.

Stocks and Shipments of Pig-Iron.—The quantity of Cleveland pig-iron in the public warrant stores here has now fallen to 6,664 tons, composed of 6,628 tons of No. 3 quality, and 36 tons of other kinds of iron deliverable as standard, and is the lowest stock recorded since Messrs. Connal and Co. took over the stores in 1877. Since the beginning of the month the stock has been reduced by 5,926 tons. Shipments of pig-iron from the port of Middlesbrough, though not heavy, are up to expectation. So far this month they amount to 22,896 tons, as compared with 21,536 tons to the same date last month, and 25,746 tons for the corresponding part of October last year.

Foreign Ore.—Large quantities of foreign ore continue to come regularly to hand, and consumers are adding to their already very substantial stocks. Imports to Middlesbrough so far this month are officially returned at 100,415 tons.

Coke.—Local demand for coke keeps heavy, but it is met by a more than ample supply. Prices are stationary. Medium kinds of blast-furnace coke still realise 28*s.* at the ovens, and up to 30*s.* 6*d.* at the ovens continues to be named for qualities low in phosphorus.

Manufactured Iron and Steel.—Producers of finished iron and steel are as busily employed as ever. In addition to work on which they have been engaged for some time past, manufacturers are now turning out a good deal of material for mercantile shipbuilding. Prices all round are strong. Common iron bars are 13*l.* 15*s.*; best bars, 14*l.* 2*s* 6*d*; double best bars, 14*l.* 10*s*; treble best bars, 14*l.* 17*s.* 6*d*; iron ship plates, 13*l.* 10*s.* to 14*l.* 10*s.*; iron ship angles, 13*l.* 15*s.*; iron ship rivets, 17*l.* 10*s.* to 18*l.* 10*s.*; packing iron and steel (parallel), 11*l.*; packing iron and steel (tapered), 13*l.* 5*s.*; steel bars (no test), 14*l.* 10*s.*; steel ship plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel ship rivets, 20*l.*; steel joists, 11*l.* 2*s.* 6*d.*; steel strip, 17*l.*; steel hoops, 17*l.* 10*s.*; heavy sections of steel rails, 10*l.* 17*s.* 6*d.*; and steel railway sleepers, 12*l.*

CONTRACTS.—Erith's Engineering Company, Limited 70, Gracechurch-street, London, state that they have received from the Ministry of Munitions an order for a very large Erith timber dryer, which they have already delivered. This is similar to their installations working at Woolwich Arsenal, and at Elswick Ordnance Works; at the works of Messrs. Vickers, Limited; Messrs. Clayton and Shuttleworth; Messrs. Ruston, Proctor; Messrs. Marshall, Sons and Co.; Midland Railway Carriage Company; and hundreds of other contractors for war supplies.

THE BRISTOL UNIVERSITY "SANDWICH" SCHEME FOR TRAINING ENGINEERS.—Dr. Wertheimer, the Dean of the Faculty of Engineering of the University of Bristol, has proposed a modified "Sandwich" system of training. A student on leaving school will enter the University and will spend a session there passing the intermediate examination for the B.Sc. degree in engineering at the end; if his record is good and he is a promising student, he will be recommended to a firm which will allow him to enter their works for a period of 14 months. This will enable the student to judge to what extent he is fitted for an engineering career, and will also enable the manufacturers to form an impression as to his suitability. He will then return to the University and continue his studies for a further period of two years—in some cases spending the long vacation in the works; after that he will return to the same works, if he has given satisfaction, for another period of 14 months.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—The secretary of this Institution, Mr. E. W. Fraser Smith, has issued a circular urging the importance of organisation at the present time, and pointing out that the Institution stands for the advancement of the interests of North-East Coast shipbuilding and engineering. He states that already the district produces fully one-half of the merchant tonnage launched in the United Kingdom and over one-third of the marine engines produced nationally, reckoning output in terms of indicated horse-power. In locomotive construction, colliery engineering, electrical engineering, &c., the district stands high in international estimation. But it is contended that better could still be done, and that this betterment could be achieved by a greater number of the shipbuilders and engineers becoming members of the Institution, so that it may become the first source of information in technical matters in the engineering and shipbuilding industries. There are many projects which are delayed owing to the want of driving power, which an increase in membership would provide, and these projects, if carried into effect, would help the district very greatly. Members are therefore enjoined not only to secure additions to the membership, but to attend meetings, offer experience in the form of papers or in the course of discussions, and present the library with books that are wanted.

NOTES FROM THE SOUTH-WEST.

Cardiff.—Weakness has been shown in secondary and lower-grade classes of coal, while the demand has been checked by a shortage of tonnage resulting from delays occasioned by prolonged stormy weather. Superior classes of coal have been still reserved, and out of the market, but in some cases sellers of secondary qualities have needed a quick clearance of trucks to save pit stoppages, and buyers in a position to take quick deliveries have been enabled to secure substantial concessions. Small coals have been in good supply and prices have been somewhat easier. There has been a good demand for house coal and prices have shown firmness; other bituminous descriptions have indicated a tendency to weakness. Patent fuel and coke have exhibited little change. The best Admiralty large steam coal has been, to some extent, nominal; secondary qualities have made 37*s.* to 39*s.*; Monmouthshire Black Veins, 38*s.* to 39*s.*; ordinary Western Valleys, 37*s.* to 38*s.*; Eastern Valleys, 35*s.* to 36*s.*; best bunker smalls, 27*s.* to 28*s.*; and cargo smalls, 19*s.* to 22*s.* per ton. In bituminous coal, best households have made 25*s.* to 26*s.* 6*d.* at the pits; No. 3 Rhondda large, 33*s.* to 39*s.*; smalls, 30*s.* to 32*s.*; No. 2 Rhondda large, 30*s.* to 32*s.*; and No. 2 smalls, 22*s.* to 23*s.* per ton. The latest quotation for patent fuel has been 42*s.* to 44*s.* per ton. Special foundry coke for export has brought 62*s.* 6*d.* to 65*s.*; good foundry coke, 60*s.* to 62*s.* 6*d.*; and furnace coke, 50*s.* to 55*s.* per ton.

Western Trade Matters.—The calling up of men in the Welsh tin-plate trade has led to a serious state of things in the Welsh tin-plate districts; fewer mills are now working than for a long time past. A deputation of tin-plate makers and representatives of their men proceeded to London on Tuesday with the view of making a further effort to influence the Reserved Occupations Committee to retain men in the trade, so as to preserve what is left of it as far as possible.—Sir W. J. Tatem presided at the sixth annual meeting at Cardiff of the Tatem Steam Navigation Company and indicated a policy of continued prudence. Quite recently, he said, a large shipping company paid a dividend for the first time in 14 years, and even the preference dividend was at one time several years in arrear. As regarded the present situation, shipowners had neither created nor manipulated high freights; an urgent demand for shipping for war purposes had withdrawn many ships from regular trade and had made the remaining tonnage exceedingly valuable for the time being. The Government had now practically taken possession at blue-book rates of all the tonnage which they required, and they had done this upon terms at which many ships were no better off than in the last few years before the war. It was essential that the shipping industry should be dealt with liberally, as our foreign competitors were already striking very hard, while they would have to be faced seriously in the future. He was disposed to agree with a gentleman of wide experience who had spoken upon the subject, and who had said that shipowners had been passing through a period of unhealthy prosperity—unhealthy prosperity because it was due to abnormal causes. Sooner or later present high freight rates would decline and shipowners must be prepared to meet competition and even adversity. The dividend, however, of the Tatem Company for 1915-16 was 15 per cent. free of income-tax, and this was equivalent to a distribution of 20 per cent.—The directors of the Blaenavon Company, Limited, recommend a dividend upon the ordinary shares at the rate of 7½ per cent. per annum for the year ended September 30; this is the first dividend paid on the shares since 1913.—Rumours have been prevalent of further contemplated colliery changes and combinations.—The Coalition Shipping Company has just been registered with an office in Mount-square, Cardiff Docks; the capital is at present upon a small scale.—The Hereford County Council has passed a resolution urging the Government to take timely measures to prevent the destruction of salmon by new shipbuilding works at Chepstow.—E. J. C. Rees and Griffin, Limited, Cardiff, have purchased the share capital of the Reid Steamship Company, Limited. The company has a nominal capital of 55,000*l.*, and it owns the Mersario steamer, 6,600 tons deadweight, and the Sidney Reid steamer, 4,530 tons deadweight; the undertaking has hitherto been managed by Messrs. Reid, Tigg and Thue, Limited. The old directors have retired and Mr. J. Sidney Rees and Mr. W. H. Griffin have been appointed to succeed them. The founder of the Reid Company was the late Mr. Sidney Reid, who carried on an extensive business in London and Southern Russia, with offices at Odessa.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—The opening meeting of this Institution for the Session 1916–17 will take place on Thursday, November 9, 1916, at 8 p.m., when the premiums awarded for papers read or published during the past session will be presented, and the eighth Kelvin lecture, "Some Aspects of Lord Kelvin's Life and Work," will be delivered by Dr. Alexander Russell, Vice-President.

CAST-IRON CONTAINING STEEL.—We read in *La Métallurgie*, Paris, whose reappearance we are very glad to welcome, that the manufacture of cast-iron containing steel is most easy and can be carried out even in small foundries. This manufacture has largely increased in France since the war began. Whilst two years ago very few foundries would have undertaken the supply of a metal showing a tensile strength of 25 kg. per square millimetre (15.87 tons per square inch), at the present time the average of 30 kg. per square millimetre (19.05 tons per square inch) is very frequently met, together with a number of stringent shock tests. The metal obtained is an ideal one for "the rapid and safe manufacture of shells."

DIESEL ENGINES FOR THE TWIN-SCREW MOTOR SHIP "ABELIA."

CONSTRUCTED BY THE WALLSEND SLIPWAY AND ENGINEERING COMPANY, LTD., WALLSEND-ON-TYNE.

(*For Description, see Page* 379.)

Fig. 3. SECTION THRO' ENGINE.

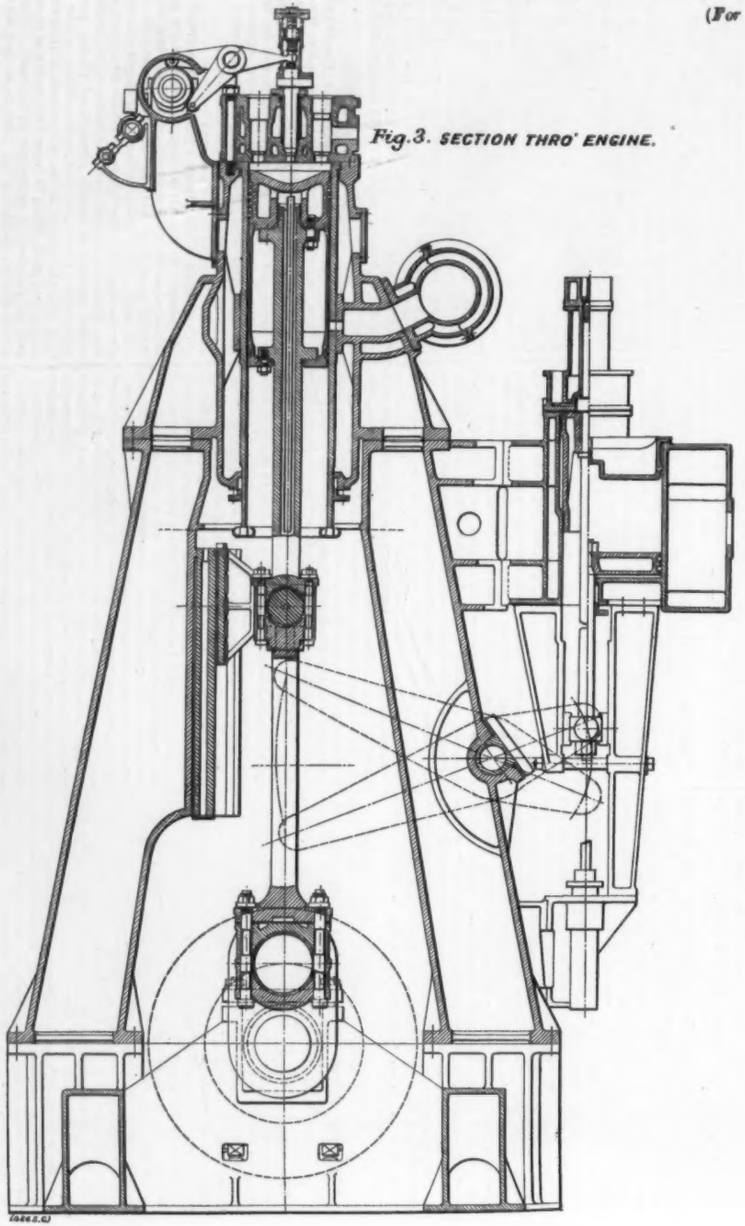


Fig. 4. END VIEW THRO' CENTRE JOINT.

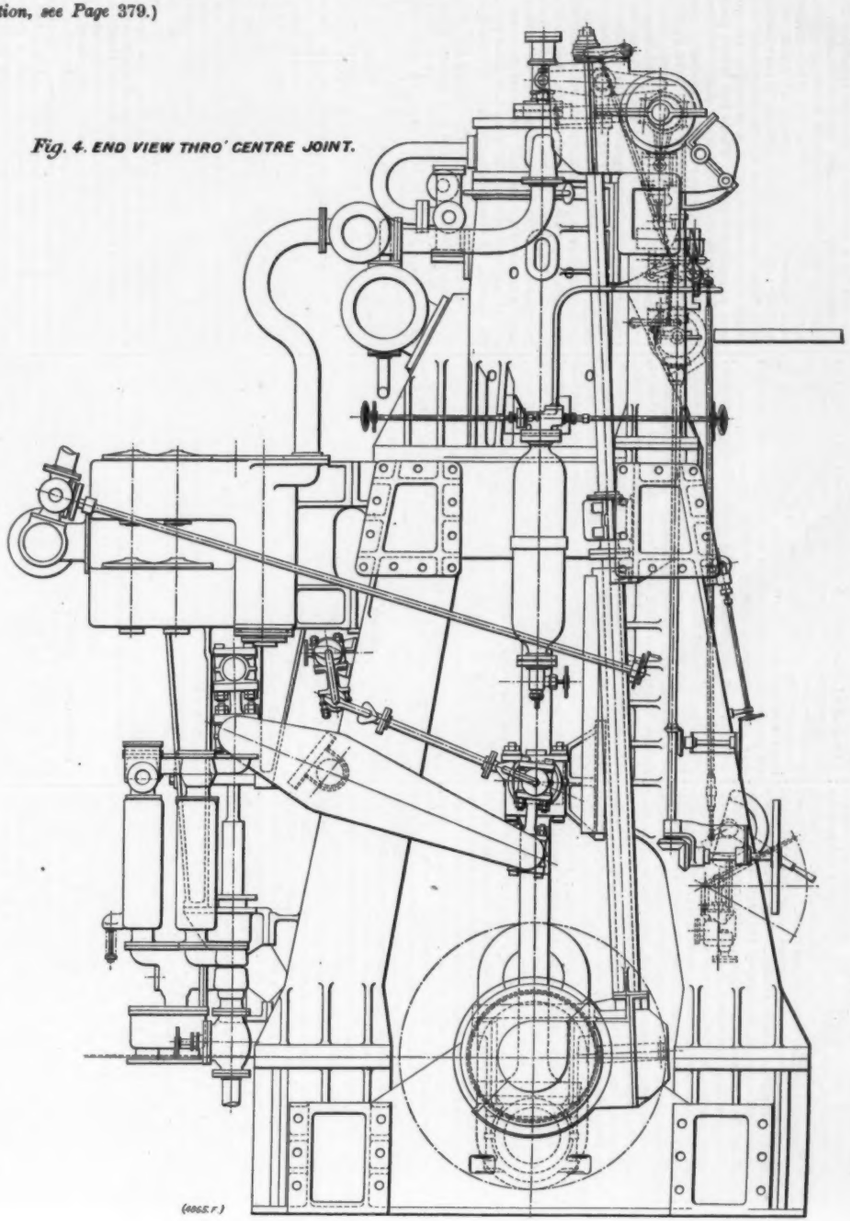


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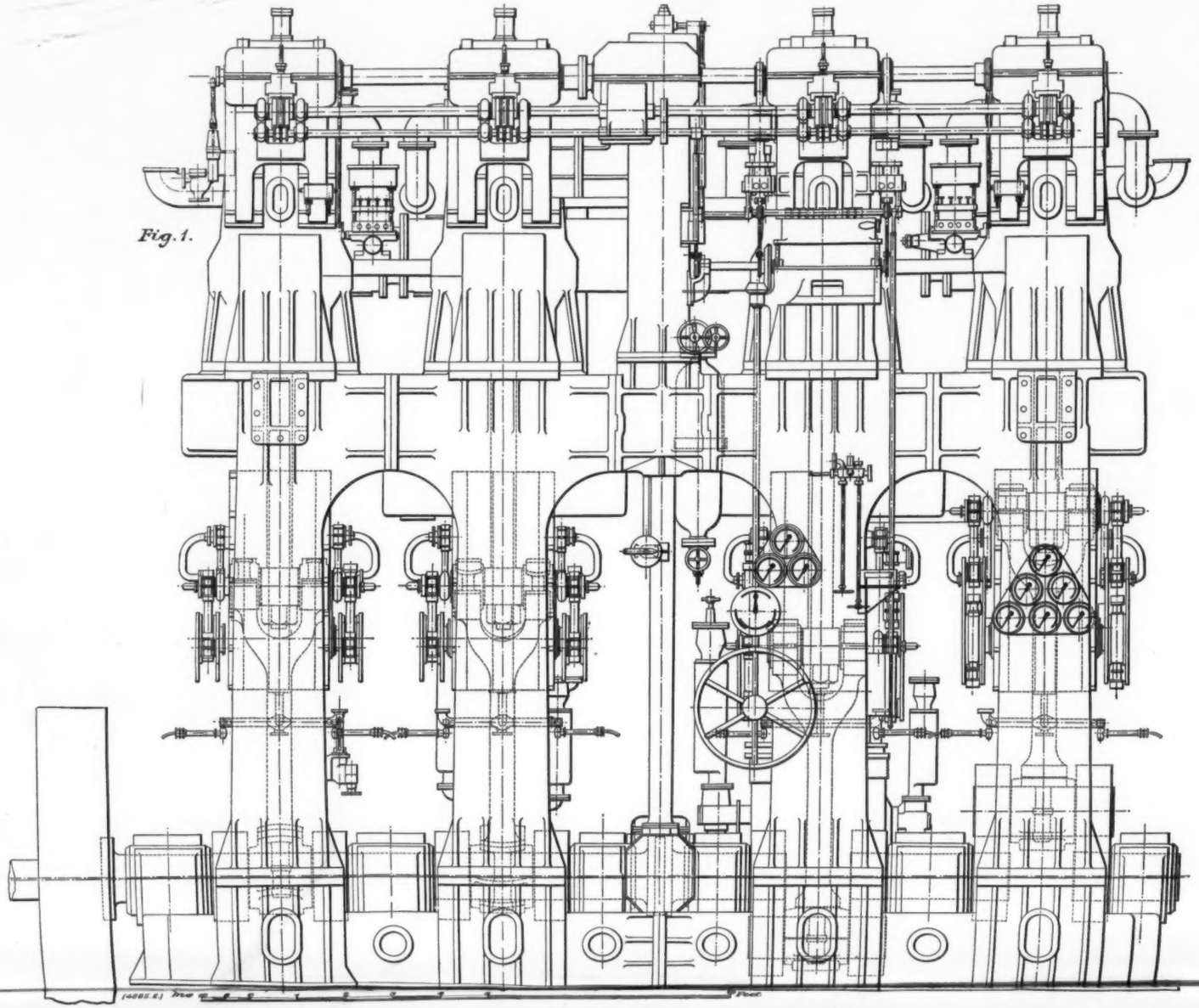
Fig. 1.



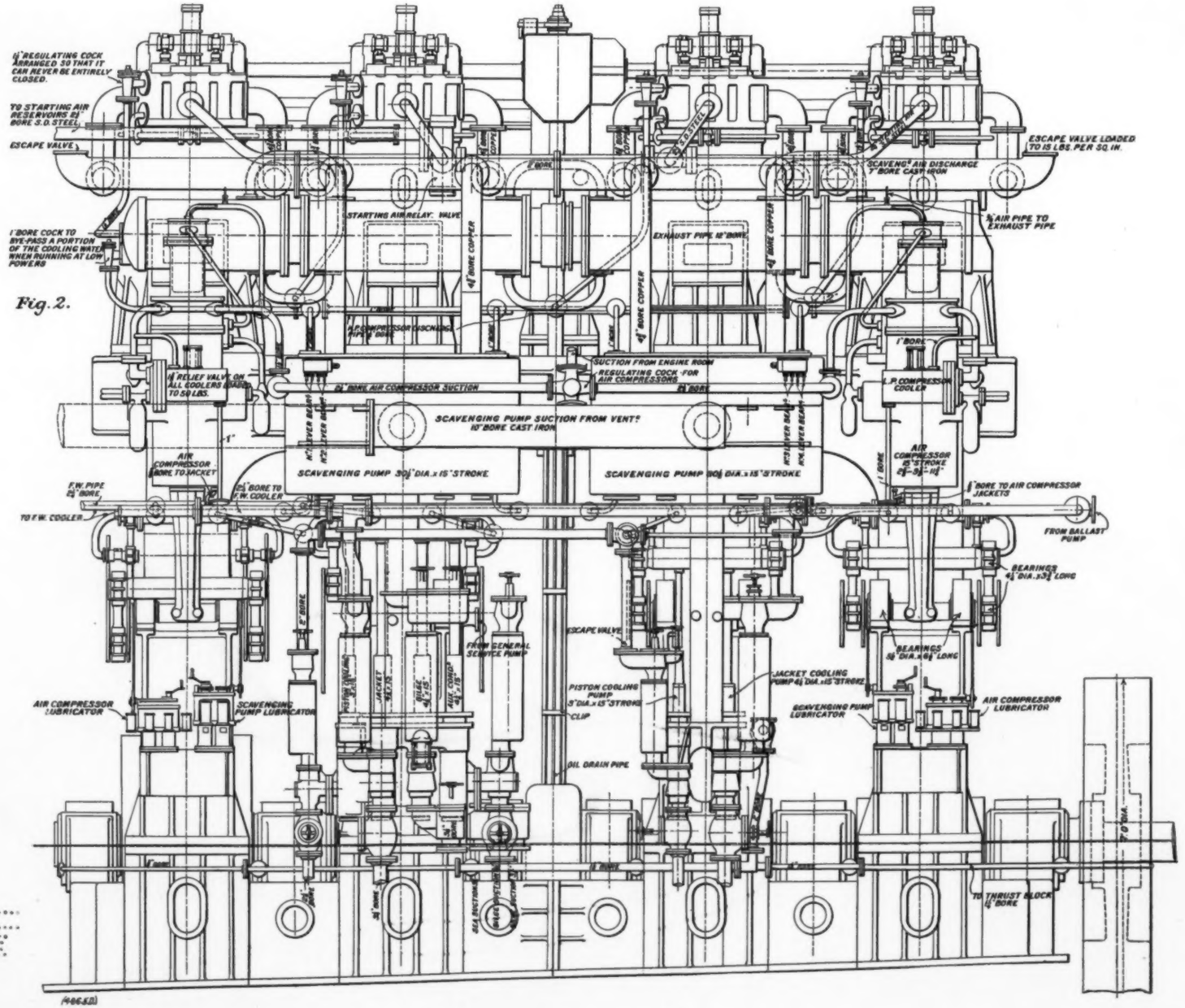

½" REGULATING COCK ARRANGED SO THAT IT CAN NEVER BE ENTIRELY CLOSED.
TO STARTING AIR RESERVOIRS 2½" BORE S.D. STEEL
ESCAPE VALVE
1" BORE COCK TO BYE-PASS A PORTION OF THE COOLING WATER WHEN RUNNING AT LOW POWERS
STARTING AIR RELAY VALVE
4½" BORE COPPER
EXHAUST PIPE 12" BORE
SUCTION FROM ENGINE ROOM
REGULATING COCK FOR AIR COMPRESSORS
2½" BORE
1" BORE
L.P. COMPRESSOR COOLER
AIR COMPRESSOR 15" STROKE 2½"-9½"-11"
SCAVENGING PUMP SUCTION FROM VENT? 10" BORE CAST IRON
SCAVENGING PUMP 9½" DIA. x 15" STROKE
SCAVENGING PUMP 10½ DIA. x 15" STROKE
AIR COMPRESSOR JACKET
2½" BORE TO F.W. COOLER
F.W. PIPE 2½" BORE
TO F.W. COOLER
¾" BORE TO AIR COMPRESSOR JACKETS
FROM BALLAST PUMP
BEARINGS 4½" DIA. x 3½" LONG
BEARINGS 5½" DIA. x 6½" LONG
ESCAPE VALVE
FROM GENERAL SERVICE PUMP
JACKET COOLING PUMP 4½ DIA. x 15" STROKE
PISTON COOLING PUMP 3" DIA. x 15" STROKE
CLIP
AIR COMPRESSOR LUBRICATOR
SCAVENGING PUMP LUBRICATOR
OIL DRAIN PIPE
TO THRUST BLOCK 1½" BORE
(4065.D)

Fig. 2.

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UNITED STATES: For Subscriptions, New York: W. H. Wiley, 432, Fourth Avenue. Chicago: H. V. Holmes, 907-958, Monadnock Block.
For Advertisements, J. S. Allan, 508, Stratford Avenue, Bridgeport, Conn., U.S.A.

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The charge for advertisements is three shillings for the first four lines or under, and eightpence for each additional line. The line averages seven words. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

SUBSCRIPTIONS, HOME AND FOREIGN.

"ENGINEERING" may be ordered from any Newsagent in town or country and at railway book-stalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months, payable in advance:—

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Thin paper copies	£1	11	6 ($7.65)
Thick "	£1	16	0 ($8.75)
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Thin paper copies	£1	16	0
Thick "	£2	0	6

When foreign subscriptions are sent by Post-Office Orders, advice should be sent to the Publisher.

All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "Union of London and Smith's Bank, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford-street, Strand, W.C.

Offices for Publication and Advertisements, 35 and 36, Bedford-street, Strand, London, W.C.

We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

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With a Two-Page Plate of the DIESEL ENGINES FOR THE TWIN-SCREW MOTOR SHIP "ABELIA."

NOTICES OF MEETINGS.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, October 20, at the Institution of Civil Engineers, Great George-street, Westminster, at 6 p.m. Paper:—"Trials on a Diesel Engine, and Application of Energy Diagram to obtain Heat Balance," by the late Lieutenant Trevor Wilkins, M.Sc., Graduate. To be presented by Professor Burstall, of Birmingham.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, October 24, at 5.30 p.m., at a special meeting, the Twenty-Fourth "James Forrest" Lecture, entitled "The Development of Appliances for Handling Raw Materials and Merchandise at Ports and other Large Centres of Traffic," by Sir John Purser Griffith, M.A.I., M.Inst.C.E., will be delivered.

THE INSTITUTION OF LOCOMOTIVE ENGINEERS.—Saturday, October 28, at Caxton Hall, Westminster. A paper will be read and discussed on "The Design and Construction of Steel Railway Coaches," by Mr. A. T. Houldcroft, Member, Manager of Steel Car Department of the Leeds Forge, and late Carriage Superintendent of North-Western Railway of India.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper, and of the consequent shortage of supplies, readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk. Owing to the scarcity of paper it will be impossible in future fully to provide for a chance demand for this Journal.

ENGINEERING.

FRIDAY, OCTOBER 20, 1916.

THE REMOBILISATION OF THE INDUSTRIAL ARMY.

WITHOUT being unduly optimistic we may assume that victory is assured within a period which justifies immediate attention being paid to the complex question of remobilising the industrial army. Within the past three or four months great progress has been achieved, particularly in overcoming that confidence of our enemies which was an important advantage in maintaining the *morale* of their fighting forces. But our most supreme effort has yet to be made, and while we think that the future reinstatement of our heroic fighters in the industrial army should be the subject of carefully devised and comprehensive organisation, we recognise that definite action must, for the present, be concentrated with ever-increasing solicitude on maintaining the effectiveness, alike in *personnel* and *matériel*, of the driving force on all battle fronts. In the one case it is a question of immediate and uninterrupted action; in the other of organisation for the future. The very complexity of the problem of remobilisation of the industrial army in the most efficient manner demands that the problem of preparation should be tackled at once.

We have preferred the phrase "remobilisation of the industrial army" to "demobilisation of the fighting forces," because it carries a fuller definition of the necessities of the case, and, moreover, indicates the line of action which ought to be taken. The War Office, no doubt, is preparing a scheme of demobilisation, but it will at once be recognised that the underlying principle of their organisation cannot achieve the best results in this case. In mobilising an army the authorities are concerned with the formation into brigades of a heterogeneous mass of men whose prior peace occupation could influence only to a minimum degree the prospect of individual efficiency as soldiers or of their aggregation into a completely satisfactory homogeneous body of troops. The War Office thinks in battalions, brigades, divisions, with all the material equipment requisite for effective opposition to the enemy. In the industrial army, on the other hand, there must be, in the interests of efficiency, almost a separate place for each individual. Certainly in the industry of a nation there is a very definite place for each grade of worker in the industrial army. It is possible, therefore, that the War Office will follow, in arranging for demobilisation, the methods of mobilisation, and will disband whole divisions or brigades, irrespective of the clamant need for a highly systematised remobilisation of the industrial army. It is therefore of the highest importance that, in this matter of vital consequence to the immediate future of industry, there should be prompt co-operation between trade organisations and the War Office. Indeed, we would go further, and make the dominant motive power in this matter the trade organisations rather than the War Office. It is not merely a question of disbanding men when the time justifies such action, but of transferring them without delay into positions in industry and commerce where their services will be most effective and will lead to a future prosperity worthy of the sacrifice each has made in the interests of humanity and international peace.

In the first place it is desirable that those industries which can more quickly influence the country's return to industrial prosperity should have their ranks reinforced to the fullest possible extent at the earliest moment. The Government already have a list of "reserved" trades where exemption from military service of the workers was more freely granted. We have here a good basis on which to work. But, even so, the importance of the industry was measured primarily from the standpoint of war supplies, so that some discrimination is needed as to whether all of these industries are essential to the attainment of maximum output in the industries of peace. There can be no question, however, that, to begin with, the miners must as quickly as possible get back to the output of coal and minerals, since these are the bases of practically all industry. The transport trades should be placed in a satisfactory condition, so that supplies may flow freely to the factories, and from the factories to the markets of the world. The immense depletion of our shipbuilding fleet justifies prompt action in augmenting the rate of building of merchant ships. As the President of the Board of Trade remarked in the House of Commons on Tuesday, we have actually lost by enemy action and by marine risks 2,000,000 gross tons of shipping since the war began, equal to a deadweight carrying capacity of 3,000,000 tons. The magnitude of this total he further illustrated by stating that it was more than the whole mercantile marine of France, or Spain, or Italy. The situation, too, is further aggravated by the almost complete cessation of merchant shipbuilding during the past two years. Even for the distribution of our forces to their homes in this country and our dominions across the sea an immense fleet will be required. It is computed, indeed, that to take the whole of the oversea forces at once would require 400 liners, which, however, are not available. Similarly, the railway rolling-stock of the country has suffered through lack of adequate repairs and upkeep, and new stock will require to be immediately put in hand. The machine-tool makers ought to be able still further to increase the volume of their work, even upon the immense production achieved during the war, because many of the new factories erected will require other machinery in order to become effective for immediate peace production, as they are equipped now in very many cases with appliances which can be used only for very definite war productions. The case of lathes for shells is one clearly illustrative of this point. There has been an enormous output of lathes, far beyond the peace needs of any community, and, moreover, a lathe for turning a large shell body is of a design unsuited, in view of the relation of strength of headstock and bed to length, for efficient application to many forms of peace work. This, too, is apart altogether from the fact that the haste with which these lathes and other machine tools had to be got together necessitated less care in the materials used and in the design, so that they are practically obsolete, even from the point of view of strength as well as efficiency. A large number of new machine tools will be required to enable the new privately owned factories to be adapted for peace production, and the sooner machine-tool makers are released the better will it be for the future industry. Thus we might go through the whole range of industrial activity. Even the new docks and harbour improvements, which have been held up for lack of labour during the war, must be hastened on by the transport to them of all available labour. Agriculture, too, must be supported in the demobilisation of the army.

The principle to be adopted in procedure is thus incontestably established as the sifting out of suitable workers for trades which must be re-established with all despatch. It will therefore be recognised that the disbanding of the army in brigades or divisions cannot possibly meet the case. In each division there must necessarily be a large proportion of men whose adaptability for the immediate remobilisation of the industrial army

will be difficult to appraise, apart altogether from the importance of first re-establishing industries of consequence to the immediate improvement in trade conditions. There are many unskilled and even unemployable men for whom work will have to be found on schemes of public improvement, which can be commenced later in the process of demobilisation. What must be avoided is the return to this country of large bodies of men who cannot immediately be absorbed efficiently in industry, and who might therefore increase our difficulties by "unemployed demonstrations." It will be a thousand times better that such men should be retained in the army until there can be found for them a definite means of earning a living consonant with the sacrifices they have made. Indeed, if care be exercised a large percentage of hitherto unemployable men may be converted into prosperous workers.

The complexity of transferring each of the 5,000,000 or 6,000,000 soldiers into a niche in our industrial life which will enable him to exercise his skill for the national benefit, as well as for his own advantage, is most obvious. The correct solution must greatly affect the prosperity of the people, and should therefore be tackled with statesmanlike breadth of view, completeness, and the greatest care. Where trades are federated, as in the case of shipbuilding, engineering, textiles and mining, the employers' federations ought to be set to work, in association with trade unions, to prepare lists of men now in the army for whom, on the attainment of peace, positions could be found at work which would immediately conduce to the establishment of industrial equilibrium. No difficulty need be anticipated regarding the extent of employment available, nor the possibility of unskilled or partly skilled or female labour being displaced. The immense wastage of 27 months of warfare has to be made up, and therefore in practically all industries there will be experienced such a demand for labour as will more than absorb the supply consequent on the demobilisation of the army. It is a question rather of effectively disposing of this labour to the best advantage from the individual and national points of view. With the lists of suitable workers prepared by employers' federations and trade unions, the army authorities could quickly discover the men, and arrange for their passage direct from the front to the bench, so that there would be no delay. On the other hand there would be the extreme satisfaction on the part of each unit of the army in finding national recognition of the duty to place him in a position to earn his living, in better circumstances, we hope, than in the past.

Objection might be taken to the difficulty of this procedure in the army, and we are glad to see that such an authority as Major-General S. S. Long, C.B., who occupied the important position of Director of Supplies and Transport, has met such possible objection with logical clearness. Anticipating the view that brigades or divisions will require to be maintained at their service strength, and that the withdrawal of a number of men from each would tend to disorganisation, he points out that day by day a large number of men from one division or another is *hors de combat* owing to casualties, and that those responsible for the maintenance of such divisions have every day practice in keeping them up to full strength. Major-General Long, in his article in the *Nineteenth Century and After* treats the subject of "right and wrong methods of demobilisation" on broad lines, somewhat corresponding to those we have indicated, and, from his service experience, he evolves a definite procedure by the army authorities. In order to enable individuals who are chosen for their adaptability to meet immediate peace requirements in the factory, he suggests that the document of discharge of each soldier might take the form of a little book with perforated pages. There would be given in duplicate an authority, signed by the demobilisation official, ordering the man's release with the group bearing the same number as that with which the document is stamped. This would be retained by the man's commanding officer, while the duplicate would be held by the soldier, to be produced at any time to show that he had been completely discharged from the army. There would also be in the booklet a warrant entitling the man to a free railway pass to the place named thereon, which would be his home where employment awaited him. Another page would contain a warrant for a sovereign to be cashed by the military authorities at the front, so that the man would have money for food while on his journey. Four other similar warrants, each for a sovereign, are to be included, these to be payable, by the post office of the town to which the man is proceeding, at intervals of one week on and after the dates named. Although it is a small detail, we would suggest that the first warrant should be payable only on the date, in order that the worker would make due haste to reach his destination. He would carry his arms, equipment and clothing with him and hand these in at the nearest military centre to his home, getting a receipt in duplicate, one to be retained and the other to be posted to the depôt of his unit. The military authorities should be responsible for sending the man in due course his discharge certificates, army character, &c., and the balance of his pay. This seems a fairly reasonable method of procedure.

Major-General Long also drafts a scheme for the setting up of a ministry of demobilisation, to include representatives of all the Government Departments concerned, as well as the representatives of industry, commerce and labour and the overseas Dominions. He also puts forward the proposal that the Premier should preside and be the connecting link between all. The immense demands made on the Prime Minister, however, are such that it is doubtful if this important position should be filled by him. The work is essentially one of detail, and we think that the employers' federations, as well as the trade unions, ought to make it their business at once to approach the War Office, so that recognition may be given to the important part they ought to play in the remobilisation of the industrial army. It is important that there should be the least possible increase in bureaucracy.

THE EVOLUTION OF THE "TANKS."

The statements in the House of Commons by the Secretary of State for War on Thursday, the 12th inst., and by Dr. Macnamara, Parliamentary Secretary of the Admiralty, on Wednesday, 18th inst., in answer to a question by Captain Burgoyne, are probably the communications promised some time ago regarding the evolution of the "tanks" to be made with the view of giving credit where this was due. It was made clear that Mr. E. H. Tennyson D'Eyncourt, C.B., the Director of Naval Construction, is entitled to full credit for designing this "formidable weapon of warfare." It would seem that a suggestion was made by several officers of the Royal Naval Air Service, as a result of experience in Flanders, to Mr. Winston Churchill, when the latter was first Lord of the Admiralty, in favour of the use of some armoured vehicle capable of traversing the irregular ground of "no man's land," of straddling over trenches and breaking down obstacles, and of scattering destruction from the guns within it, while being itself reasonably protected against gun fire. Mr. Churchill, with that characteristic freedom of mind for the reception of new ideas, and courage for putting the potentialities of all such proposals to the test, gave heed to the suggestion. But in mechanics an idea is one thing; the evolution of the details of design to carry the idea into practical effect is quite another. The history of invention shows a great store of ideas incapable of application, as well as a rich record of long-entertained ideas successfully applied. The suggestion of caterpillar wheels is old, and has long been applied for the traction of guns over moderately irregular ground. Many proposals for movable forts with such caterpillar wheels have been put forward from time to time, and we are amused to find that some of the suggestions by Americans have actually been published as illustrative of the system adopted in the "tanks" of the British Army now in use in France. The Americans claim that they are their invention, and, in fact, that they were manufactured in the United States. Germany also lays claim to the origination of the idea. In connection with the question asked by Colonel Griffiths in the House of Commons on the 12th inst., as to whether the "tanks" were entirely of British material, it is of interest to point out that everything was of British design and manufacture.

While it is not permissible to enter into any details regarding the wonderful engineering features in the design of the "tanks," it will be found that the ingenuity displayed in securing the long wheel base on the caterpillar chain principle is exceedingly novel and worthy of the highest tradition of British inventive ingenuity. When Mr. Churchill instructed Mr. Tennyson D'Eyncourt to prepare the design, the great limitations of former proposals were freely recognised, and there can be no doubt that the then First Lord of the Admiralty rendered great service in the masterful encouragement which he gave to the Director of Naval Construction. During the preparation of the design and experiments Mr. D'Eyncourt suggested the appointment of a small Admiralty Committee, which should consult with representatives of the War Office as to the military conditions to be fulfilled. This Mr. Churchill at once agreed to, making the Director of Naval Construction the chairman of the committee, whilst the secretary was Lieutenant (now Lieut.-Colonel) A. G. Stern, whose practical business ability, as Mr. Lloyd George said, had been invaluable in securing the manufacture on a considerable scale of this weapon of war. Colonel Swinton also, according to the Secretary of State for War, has been a most enthusiastic supporter of the idea, and the fact that it was carried through with such zeal was very largely due to the enthusiasm which he threw into the work. All through the evolutionary stage Mr. Churchill, the First Lord of the Admiralty, took a very active part, stimulating all concerned, and when the proposal for representatives from other Departments was made, Mr. Lloyd George gave the scheme his unstinted support. Mr. Balfour, when he went to the Admiralty as First Lord, equally supported the work of design and experiment. The other officers mentioned by Dr. Macnamara as assisting in the work were:—Commodore Sueter, Wing-Commander W. Briggs, Squadron-Commander T. G. Hetherington, Mr. W. O. Tritton (managing director of Messrs. W. Foster and Co., Limited), Lieutenant W. G. Wilson, R.N.A.S. (now Major Wilson, M.G.C.), Mr. P. Dale Bussell (Contract Department, Admiralty), Lieutenant A. G. Stern, R.N.A.S. (now Lieut.-Colonel Stern, M.G.C.), Captain Symes, M.G.C., and Mr. F. Skeens, Acting Assistant Constructor.

It was as far back as the summer of last year that the first "tank" was ordered to be made from Mr. Tennyson D'Eyncourt's design. The results of the trials were very satisfactory. The late Lord Kitchener, as well as the Lords Commissioners of the Admiralty and Mr. Lloyd George, were particularly pleased with its attainments. When the Army authorities became convinced of the utility of the machine on the battlefield, it was decided to build a number of such landships from the same designs. It was at this time very properly decided that the supervision of construction should be under the control of the Ministry of Munitions, and a committee of that Department was appointed to carry out the work. Lieut.-Colonel Stern, who had before acted as secretary of the Director of Naval Construction's Committee, was made chairman of the new committee, while Colonel Swinton took over direction of *personnel*. At the request of the Ministry of Munitions, and with the approval of the Admiralty, Mr. Tennyson D'Eyncourt continued as a member of this committee, and was, and is still, chief technical adviser, and no doubt has worked out further developments of the "tank." When it is possible to disclose the details of the design, it will no doubt be seen that in most of these details there is great originality, and that naval architectural experience has in this, as in other respects, greatly assisted the army in the field. The secrecy with which the operations have been carried out merit high tribute, not only to those immediately engaged in the designing work, but also to the workers who have been employed in construction. Although Mr. Lloyd George could not enter into any details as to his association with the idea, it is only fair to say that that vigour which has ever actuated him was an important factor in the carrying through of the work of constructing the "tanks" which have been so invaluable, and promise to continue to be invaluable, at the front.

PEAT POWDER AS LOCOMOTIVE FUEL.

There are vast peat deposits in Sweden, and with the present price of coal it is only natural that the State railways should endeavour to make use of them. Experiments have therefore been made with this fuel on a goods locomotive, of which the following are the particulars :—

Cylinders—diameter ...	19½ in.
,, stroke	25 ,,
Wheels, driving (eight-coupled)	54 ,,
Steam Pressure	170 lb.
Heating surface—	
Fire-box	115 sq. ft.
Tubes	996 ,,
Superheater tubes	301 ,,
Number of tubes—	
(1.97–1.58 in.)	118
(5.15–4.8 in.)	18
Length between tube plates	13 ft. 1 in.
Tractive force $\frac{0.65\ p\ d^2}{D} \times l$...	9 tons (metric)
Adhesion weight (per axle) ...	11.2 tons
Weight of locomotive ...	51 tons (metric)
,, tender	36 ,, ,,
,, water	14 ,, ,,
,, peat powder ...	4 ,,

The peat powder is carried on the tender in a hopper with a conical bottom. Beneath the bottom is a pipe, through which the peat powder is blown to a nozzle opening into the fire-box by means of air, compressed by a steam blower. By firebrick partitions the fire-box was subdivided into an ignition chamber, two side passages and an upper chamber, through which the products of combustion pass and are led to and fro before they enter the tubes. For the ignition of the peat powder there is, under the nozzle through which the peat is blown, a small grate carrying a coal fire. The consumption of coal for this purpose averages 3 to 4 per cent. of the weight of the peat powder.

The ordinary exhaust nozzle in the smoke-box did not work satisfactorily with peat powder, and had to be modified. A spark catcher was not fitted, as the sparks are so small and light that they are extinguished before they reach the ground. As a matter of fact there are no sparks at all from the peat powder when the firing is properly attended to.

As the result of some previous experiments, 1.4 lb. of peat powder were considered to possess equal heating value to 1 lb. of British coal. To arrive at a more accurate and definite result, these tests were undertaken, the locomotive in question having been in use for some time. The tests were made on the Hallsberg–Mjölby section (60 miles) between two locomotives of the same type, peat powder being used in the one and coal in the other. The programme for these tests stipulated for a goods train of 700 tons weight being run at normal service speed, which was taken as averaging 22 miles per hour. The train was to consist of wagons loaded with coal, and each type of locomotive was to make three journeys. An alteration was made at the last journey, when the train was composed of bogie passenger carriages, the weight being 300 tons, and the average speed being 34 miles per hour. On the test section there is, over a distance of 3.6 miles, a rising gradient of 1 : 100 with numerous small curves with radii of from 1,000 to 1,500 ft. The speed was here reduced to 8½ miles per hour for the goods train and to about 20 miles for the passenger train. Steam pressure and water level in the boiler could, it was proved, be maintained through the whole of this gradient.

The consumption of water was read from a scale fitted to the tender tank; the results consequently include the losses from starting of the injector and the consumption of the steam-worked blower on the peat-powder locomotive. The consumption of fuel was recorded by weighing before and after each half of a journey. In order to ascertain the heating values, samples of the fuel were taken on each journey. The results gave an average of 7,920 B. Th. U. for the peat powder and 13,030 for the coal. The analyses showed the following results :—

	Peat.	Coal.
Carbon	47.0	73.5
Oxygen	29.5	4.4
Hydrogen...	4.5	8.6
Sulphur	0.5	1.5
Nitrogen	1.1	1.2
Ashes	3.2	6.2
Water	14.2	4.6

As the consumption of water and the heat transmitted to the steam were not the same on the two comparative journeys (see table), the consumption of fuel per 1,000 train-kilometres was reduced to the same water consumption and heat transmission. Some allowance must also be made for the locomotive with coal fuel being quite new, whilst the other had been in use for some time, and therefore was less favourably conditioned.

The annexed table shows the most important results of the tests. It will be noted the superheat temperature of the steam is higher with the locomotive fed with peat-powder fuel than with the one with coal, which is owing to the fact that peat powder burns with a longer flame than coal, and to the temperature of the products of combustion in the former case being higher than in the latter. A calculation of the boiler efficiency and the temperature of the fire-box gives for the locomotive for peat powder respectively 0.73 per cent. and 1670 deg. C., and for the locomotive for coal 0.688 per cent. and 1510 deg. C. Both figures, it will be seen, are higher for the former, which again means that the heating value of the peat powder is better utilised than that of the coal. The main object of the tests was to ascertain the consumption of peat powder as compared with that of coal for the production of the same quantity of steam and in doing the same work. To attain this it was necessary to reduce the observed steam production per kilogramme of fuel to what it would have been with the same total heat content, taking as standard the total heat of steam at 190 deg. C., reckoned as 665 calories. The calorific value of the fuel also had to be referred to a proper standard, and 7,740 British thermal units were chosen for the peat powder, and 12,600 British thermal units for the coal. The reduced values will be found in the two last rows in the table annexed. In reducing the figures for the coal-fired locomotive, regard has been had to the fact that the locomotive was a new one, wherefore its efficiency was somewhat modified. Tests have shown that locomotives of this type on an average give about 6.3 lb. superheated steam per lb. of coal; a re-calculation gives an efficiency of 0.65 instead of 0.685, which has been taken into consideration.

The final result deduced from the table is this, that the same quantity of steam can be obtained from $\frac{6.81}{4.71} = 1.45$ lb. of peat powder as from 1 lb. of coal, when the respective values are 7,740 British thermal units and 12,600 British thermal units, and the boiler efficiency is respectively 0.73 and 0.65.

With a supply of 4 tons of peat powder, which the tender can hold, a goods train of 650 tons and a passenger train of 300 tons behind the tender can be hauled respectively 62 and 81 miles.

Fuel.	Trip.	Direction.	Weight in Tons. Locomotive, Tender and Carriages.	Weight in Tons. Carriages.	Number of Axles.	Consumption in Kilogrammes. Water.	Coal.	Peat Powder.	Consumption in Kilogrammes per 1,000 train-Kilometres, including Locomotive and Tender. Coal. Observed.	Coal. Reduced to Standard.	Peat Powder.	Steam Pressure, Atmospheres.	Temperature of Steam. Deg. C.	Total Heat of Steam.	Temperature in Smoke-box. Deg. C.	Draught in Millimetres (Water Gauge). Fire-box.	Smoke-box.	Heating Value. Peat Powder.	Coal.	Kilogrammes of Steam per Kilogramme Fuel. Real. Peat Powder.	Real. Coal.	Reduced. Peat Powder.	Reduced. Coal.	Average Speed per Hour. Kilometres
Peat powder	I.	H M	787	700	78	12,600	80	2,712	—	—	37.5	12.1	332	740	255	20	86	7,808	—	4.25	—	4.69	—	29.2
		M H				9,600	68	2,277	—	—	31.4													
Coal	II.	H M	782	700	78	12,550	1,855	—	24.8	25.6	—	11.5	293	719	290	14	47	—	12,924	—	6.83	—	6.83	27.5
		M H				9,350	1,351	—	18.1	19.1	—													
Coal	III.	H M	782	700	78	13,300	2,021	—	27	27.7	—	11.6	300	723	312	22	60	—	13,284	—	6.7	—	6.55	28.7
		M H				11,000	1,609	—	21.5	23.4	—													
Peat powder	IV.	H M	787	700	78	13,250	87	2,947	—	—	40.7	11·9	336	742	294	—	—	7,880	—	4.35	—	4.77	—	27.0
		M H				11,750	76	2,550	—	—	35.2													
Peat powder	V.	H M	387	300	40	9,400	61	2,016	—	—	56.9	11.8	331	740	289	15	101	8,078	—	4.38	—	4.67	—	42.5
		M H				8,700	58	1,940	—	—	54.6													
Coal	VI.	H M	382	300	40	8,900	1,312	—	35.8	39.0	—	11.5	298	722	268	16	52	—	12,880	—	7.0	—	7.05	41.7
		M H				7,800	1,067	—	29.1	33.1	—													
Average	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	7,920	13,030	4.33	6.84	4.71	6.81	—

NOTES.

Dry Dock Pumping Plant at Panama.

A series of tests has been carried out with the pumping plant at the dry dock No. 1, Balboa, says *The Canal Record*. The plant comprises four 54-in. main pumps and two 20-in. drainage pumps, each with a vertical induction motor, all housed, together with the necessary accessories and the motor-driven air compressors, in the building on the south wall of the dry dock at its entrance. The conditions entered into with Mr. H. R. Worthington, contractor for the entire plant, require that each main 54-in. pump shall discharge an average of 11,100 cub. ft. per minute of sea water when pumping against a rising tide, which tide is specified to reach an elevation + 8.5 when the dry-dock floor, at elevation — 39.5, is bare of water. The average overall efficiency of these units is guaranteed to be 64.5 per cent., including all losses in motors and pumps. The 20-in. drainage pumps are required to have an average capacity of 1,375 cub. ft. each, with an overall efficiency of 64 per cent., when pumping from the culvert below the floor of the dry dock, from elevation — 42 to elevation — 52 with the tide rising from elevation 0.0 to elevation + 8.5. It was found that with 35 ft. of water in the dock, one main pump can lay bare the floor in 5 hours and 10 minutes. On July 18, at 4.20 a.m., all four main pumps were run at once, starting with about 47 ft. of water in the dock; on this run, the dock was emptied in 1 hour and 45 minutes. The drainage pumps emptied the culvert under test conditions in about 2 hours and 40 minutes, showing them to be above the specified capacity. While the complete computations have not yet been finished, sufficient calculations have been made to show that each unit exceeds the guaranteed capacity and efficiency. The pumping plant, with the air compressors controlled from the same switchboard, constitutes the largest single electric load on the Isthmus. If all pumps and compressors are running, a total of about 7,500 h.p. is required, or almost the entire present output of the hydro-electric installation.

Manchester Association of Engineers.

The inaugural address of this Association was delivered on Saturday last by the President, Mr. F. W. Reed, M.I.Mech.E. He intimated that the High-Speed Tool Research Committee was

continuing its work, and in a report would shortly deal with methods of heat treatment of high-speed steel. The Research Committee of the Privy Council have recognised the importance of this work by a grant of 440*l*. Mr. Reed proceeded to deal with the economic problems of the moment, with particular reference to reorganisation for trade after the war. He spoke of the encouraging results arising from the manufacture in this country of dyes, optical and chemical glass, porcelain articles of trade and magnetos, the manufacture of all of which had drifted into the hands exclusively of the Central Powers, and he augured from the successful institution of these industries in this country that valuable future developments would be made and would succeed. He, however, thought that the Government Department dealing with trade required reorganisation, with a view not only of extending trade, but of improving the relationship of Capital and Labour. He was opposed to equality of remuneration, contending that the scheme of rewarding individual effort in the machine shop was most necessary. "The value of services rendered," he said, "should not be measured by the time made, but by the work done. Good wages," he continued, "is a forward policy; it attracts the best labour and retains it, and, generally speaking, ensures the most economical production. Wage rates in the present abnormal conditions are high, and are not economically sound, since the nation's expenditure is greater than its income, and its resources are not being developed to give a corresponding increase in the purchasing power of the recipient of these increased wages. These present rates have been termed war rates, indicating that they may rule until the cessation of hostilities, when a readjustment may have to take place. This, we sincerely trust, will not be a source of friction, particularly at a time when there will be the greatest need for industrial peace, and when it would be national folly to resort to strikes or to interference with national industrial activity. In dealing with the question of wages it is fundamental that confidence should exist between the employer and employed, based on common sense, frankness, and a disposition to give and take." The following, in Mr. Reed's view, were some of the questions which call for solution:—(1) To consider and come to a general understanding in reference to apprentices in all the various branches of the engineering trades. Sufficient attention was not paid to the matter of encouragement and training of our apprentices in general and technical education as well as in their workshop practice. (2) To consider the matter of making the best use of adult and other labour which has become trained in mechanical operations during the war, and the advisability of introducing such adult labour as in the opinion of the management might be useful operators in an engineering works, and to arrange for the grading and progression of these workers. (3) To make arrangements for rewarding individual effort. He thought that these problems might be tackled by a central engineering board, composed of representatives of employers and labour, whose business it would be to arrange rules and regulations to govern employment to suit modern conditions. Such a board, too, might also form a final Court of Appeal for the settlement of disputes referring to labour and wages. There are many boards already, and it seems very doubtful if one added to the number will achieve results; the difficulty, rather, in our opinion, is to secure action by the boards that exist.

Our Locomotive Exports.—The exports of locomotives from the United Kingdom continue to show a severe falling-off, the value of the shipments in September having been only 97,268*l*., as compared with 290,900*l*. in September, 1915, and 287,618*l*. in September, 1914. The aggregate value of the exports to September 30 this year was 923,955*l*., as compared with 2,079,121*l*. and 2,929,502*l*. respectively. There has been some revival in the delivery of locomotives to Argentina, the value of the shipments to that country in the first nine months of this year having been 173,658*l*., as compared with 138,216*l*. and 603,786*l*. Our deliveries of locomotives to India have, however, been quite paralysed by the war, their value to September 30 this year having been only 210,303*l*., as compared with 1,111,392*l*. in the first nine months of 1915. Australia took locomotives, or parts of locomotives, to the value of 127,654*l*. to September 30 this year, as compared with 62,959*l*. and 430,950*l*. respectively.

THE LATE MR. DAVID COLVILLE.

We regret to have to place on record the death of Mr. David Colville, managing director of the well-known steel manufacturing firm of Messrs. David Colville and Sons, Limited, of Motherwell. Mr. Colville had lived during the past two years a very strenuous life in connection with the supplies of steel, not only for the British Navy and Army, but also for those of our Allies, especially France. He had worked continually, taking no holidays and little relaxation, and on Saturday forenoon last was taken suddenly ill in the office of his firm's establishment. He was removed to his home, Jerviston House, Motherwell, but never rallied, and died on Monday morning, in his fifty-seventh year, leaving a widow, a daughter, and a son—a Lieutenant in the Argyll and Sutherland Highlanders, who has been awarded the Military Cross, in addition to being mentioned in official despatches.

Mr. Colville was the youngest of the three sons of the late Mr. David Colville, who founded the Dalzell Works at Motherwell in 1871. The eldest son, Mr. John Colville, who was a Member of Parliament for a considerable time, died in 1901; while the second son, Mr. Archibald, is now the chairman of the company. Mr. David Colville, whose death we now record, was, like his brothers, trained to the business, and entered it as a young man about the time (in 1880) when a steel-making plant was being added to the Dalzell Works. His exceptional ability and training justified the confidence reposed in him in connection with the superintendence of this addition to the works. He had visited America and several Continental countries, studying plant and practice in connection with the production of metals. He was a close student of steel-making practice generally. He was broad-minded, and readily applied those developments which experience had proved would add to the reliability of the metal, to economy in manufacture, or to the lessening of fatigue by the workers. Thus the firm gained a high reputation for the manufacture of steel of all kinds, notably bars and plates for merchant and war ships. The demands in connection with the war, in association with the successful management of the Dalzell Works, resulted in the firm taking over the Glengarnock Iron and Steel Works and the Clydebridge Works (both in the West of Scotland) in order to increase their supplies to the British and Allied Governments. It may be added that Mr. Colville practically devoted all his attention to the affairs of the company, and, although a member of the Iron and Steel Institute from 1883, did not take any part in the proceedings.

Customs Tariffs of Mexico.—A Supplement to the *Board of Trade Journal* of the 19th inst. contains a translation of the Customs tariff of Mexico, as amended by, and annexed to, the Mexican Decree, dated July 31, introducing extensive alterations in the Customs tariff of that country. The rates of duty established by the revised tariff are to come into force as from November 1.

Prohibited Imports.—The *Board of Trade Journal* of the 19th inst. contains a complete list of articles, the importation of which into the United Kingdom has been prohibited, except under licence, by Royal Proclamations of February 15, 1916, and subsequent dates, and in respect of which applications for licences should be addressed to The Controller, Department of Import Restrictions, 22, Carlisle-place, Westminster, London, S.W. It contains also a revised list of "Interpretations" made by the Department.

Test of the Willans Rotary Air Pump Plant.—The following are the results of tests carried out on one of five similar surface condensing plants with Willans Rotary Air Pump system, installed at the Durnsford-road Power House of the London and South-Western Railway Company. This system was described in detail in our issue of November 12, 1915. The tests were carried out on August 20, 1916, in the presence of the representatives of the consulting engineers, Messrs. Kennedy and Donkin, and of Mr. Herbert Jones, chief electrical engineer to the London and South-Western Railway Company.

Trial number	1.	2.	Guarantees.
Duration of test	60 min.	60 min.	—
Load, lb. of steam per hour	68,176	68,389	68,000
Vacuum at steam inlet to condenser, corrected to 30-in. barometer	28.73in.	28.76in.	28.5in.
Corresponding steam temperature	86.6° F.	86° F.	92° F.
Condensate temperature	82° F.	82.5° F.	87° F.
Difference between condensate and vacuum temperatures	4.6° F.	3.5° F.	5° F.
Circulating water inlet temperature	58.5° F.	58.5° F.	65° F.
Circulating water outlet temperature	80.8° F.	81.1° F.	83° F.
Difference between circulating water outlet and vacuum temperature	5.8° F.	4.9° F.	9° F.
Cooling water, gallons per hour	318,000	317,600	396,600

At the date of the test the plant had already been in service for a considerable period.

INDUSTRIAL NOTES.

The Director of the Department of Labour Statistics, dealing with the labour market in the *Board of Trade Labour Gazette*, states that in September all the principal industries were well employed, while those engaged on Government contracts continued to work at high pressure. In a few minor trades or branches of trades there was some slackness, but in no case was there an appreciable number of unemployed. Compared even with the good conditions of a year ago employment on the whole showed an improvement. The substitution of women and girls for men continued, but the depletion of industry, owing to increased enlistments, necessitates their employment in much greater numbers if industrial requirements are to be met.

The changes in the rates of wages reported as taking effect in September were all increases, and affected nearly 200,000 workpeople, resulting in a total increase of over 23,500*l*. per week. The largest bodies of workpeople included in the statistics were linen and jute workers at Dundee, boot and shoe operatives at Northampton, ship repairers on the Thames and Mersey, engineers and shipbuilders at Belfast, engineers at Sheffield, and wool combers and carders at Bradford.

The total number of disputes beginning in September was 36, and the total number of workpeople involved in all disputes in progress was 11,959, as compared with 21,096 in the previous month, and 52,869 in September, 1915. The estimated total aggregate duration of all disputes in progress during the month was 180,300 days, as compared with 78,900 in August, 1916, and 172,400 in September, 1915.

The average weekly number of vacancies notified to all Employment Exchanges for the four weeks ended September 8 was 38,717, as compared with 39,113 in the previous four weeks, and with 34,957 in the four weeks ended September 10, 1915. The average weekly number of vacancies filled for the same period was 31,156, 30,846, and 25,534 respectively.

During September the retail prices of food in the United Kingdom showed an average increase of about 2 per cent. Taking the country as a whole, and making allowance for the relative importance of the various articles in working-class household expenditure, the average increase in the retail prices of food since the beginning of the war is 68 per cent. In Berlin, the general level advanced in August by 0.4 per cent., as compared with the previous month, and stood at a point 116 per cent. above the level recorded for July, 1914. In August the general level in Vienna rose to about 178 per cent. above that for July, 1914. For 31 articles of food considered in the case of 44 Swedish towns, the extent of the increase in prices in the period July, 1914, to July, 1916, was 54 per cent.

The consequences of the recent surrender of Congress to the railway unions became quickly apparent, says the *Engineering and Mining Journal*, New York. In New York there had previously been a strike of traction employees, which had been settled by mutual agreement. After the passage by Congress of the eight-hour law, so-called, the leaders of certain unions decided that they would call a new strike in order to demonstrate their authority. The strike was called, but out of about 13,000 employees only 3,000 went out. In the course of a few days the strike had proved a fiasco. The labour leaders then resorted to their usual tactics, the first step being to excite disorders, but these were promptly suppressed by the police. New York, adds our contemporary, fortunately has a mayor with a backbone.

The Ministry of Munitions announce that, as a consequence of the new arrangements in the Employment Department of the Board of Trade, the following appointments have been made by the Minister of Munitions:—Mr. Stephenson Kent to be Director-General of Munitions Labour Supply. Mr. U. Wolff to be Deputy Assistant General Secretary to the Ministry. Mr. Kent will deal generally with matters affecting labour supply; Mr. Wolff with labour questions arising under the Munitions Acts.

The action of the Executive of the Cleveland Miners' Association in declining to call a conference to consider the question of running a Labour candidate against Mr. Herbert Samuel, the Home Secretary, says the *Yorkshire Post*, is referred to in a letter from the front to a Redcar citizen, sent by Councillor R. Reyner, of Boosbeck, a local miners' leader, who is now serving with the Tunnelling Company of the Royal Engineers. "I picked up on going to the trenches a piece of newspaper stating that the Cleveland miners are threatening to run a candidate at the next election. My feelings in that direction are well known, but there are no politics here—nothing but the greatest unity. What I would

like to say to those at home is that there is now something even of more importance than politics. Politics can wait until after the war is won and German militarism is laid low, never to rise again. There will certainly be a better chance of victory, and it will come more speedily, if those at home will show the same spirit as out here, where English, Irish, Scotch and Welsh—Liberals, Labourites, Conservatives and Nationalists—have only one aim and object, the defeat of a common foe. They have something more important to do than quarrel over politics. There will be plenty for the workers to do after the war, but for the present, even if the representation remains unchanged, we cannot afford to miss the great point of unity."

A circular has been issued by Mr. E. W. Fraser Smith, Secretary of the North-East Coast Institution of Engineers and Shipbuilders, stating that if it be necessary to have organisations for the upholding of economic interests, it is much more necessary to have an efficient organisation for the furthering of the technical interests of the industries. Unless we organise for peace, he added, the "outbreak of peace" might imperil our supremacy, just as that of war took us unawares. He made an appeal to increase the growth of the Institution.

At the meeting of the Manchester Association of Engineers on Saturday last, the 14th inst., Mr. F. W. Reed, the president, dealing with the question of female labour in mechanical shops, stated that the capture of enemy trade was a question of output rather than of total employment. In normal times we had only about 4 per cent. of unemployed, and if employment were found for these it could not be expected that we should be able to accomplish anything but a small fraction of the extra trade contemplated after the war unless an understanding were come to between employer and labour to ensure greater individual output. It would be to the interest of the employer to discard out-of-date machinery and replace it with modern; more especially was this advisable with high wage rates. Further, it was not good economy to employ fully skilled men on work which could be equally well done by semi-skilled men or women. The important part women had taken in helping to carry out extra and unusual work which the war had brought about was an important industrial factor. They had adapted themselves to the novel conditions and had proved themselves capable of keeping pace with male labour on repetition work, even to the extent in some cases of giving better results. He particularly referred to output rather than to production costs. Not only had they shown themselves capable of success in engineering works, but they had taken the place of other male labour. No doubt a number of women who had been working from purely patriotic motives would resume their former occupations, but others would have a strong desire to continue working in the mechanical trades. Only in rare cases were women doing the work of skilled men; in general they were employed on work of a repetition nature, but the skill which they had displayed afforded reason to believe that they could be qualified for more responsible work by a proper system of more prolonged training.

A return recently issued by the Employment Department of the Board of Trade shows that in April, 1916, the number of women reported by employers as directly replacing males in all occupations in the United Kingdom was 547,000, the total in all occupations reaching 766,000 in July, 1916. The gross increase in the number of women employed in industrial occupations since July, 1914, was 362,000, but of this latter figure only 263,000 were directly replacing men in July, 1916. In commercial occupations 201,000 women were directly replacing men, also in July, 1916, as compared with July, 1914. The replacing of men by women is again increasing in a great variety of industrial occupations.

The Ministry of Munitions has issued a White Paper containing a report by Dr. Leonard E. Hill on investigations carried out by him on behalf of the Health of Munition Workers Committee. After explaining the theories of dietary and the amounts of the various classes of food required to maintain full working power in men and women, Dr. Mill states that he visited a number of canteens attached to munition works and obtained data from other sources. He mentions a number of dishes, showing their calorific value and cost. The average canteen dinner, he says, is a good one. The cost compares favourably with café or restaurant charges, and so the worker gains in pocket and obtains a dinner of good food well prepared. He investigated also the nature and energy value of food brought by workers from their own homes. The specimens obtained from workers showed a good average energy value, and the committee remark that these meals are often supplemented by odd articles bought at the canteens. A comparison is made between two samples of women's meals. The first was from a women's restaurant, where roast mutton, boiled potatoes, cabbage and syrup roll were obtained for 6*d.*; and the second at a women's teashop, where roll and butter, milk, sugar, stewed prunes and syrup were obtained for 7*d.* The energy value of the first meal was reckoned as 68.7, while that of the second was only 39.7. In order to afford assistance to caterers for munition workers, a series of simple but adequate meals is tabulated, the cost being from 2*s.* to 2*s.* 2½*d.* per day.

As previously announced in the Press, the Board of Trade have had under consideration an application by the Forest of Dean Joint Minimum Wage Board for a further increase of 4*s.* in the standard amount under the Price of Coal (Limitation) Act, 1915, in respect of the mines in their district. The standard amount was increased from 4*s.* to 5*s.* for this district in September, 1915, in order to avoid a reduction of wages under the wages agreement in force. The present application for a further 4*s.* was based on the increase of working costs in the district, the chief item being an increase in wages of 20 per cent. on the standard which was recently granted by the mine owners in order to bring the wages into closer relation with those prevailing in neighbouring districts. The fact that the application was under consideration was announced in the Press on September 27. One objection was subsequently received by the Board of Trade, but was withdrawn. The Board, after inquiry, have raised the standard amount for the district from 5*s.* to 6*s.* 6*d.*

The L 33 Zeppelin.—According to *The Times*, the Zeppelin which came down on September 24, in Essex, has a framework or skeleton composed of a series of longitudinal lattice-work girders running from end to end and connected at intervals by circular lattice-work ties, the whole structure being bound together and stiffened by means of a system of wires provided with arrangements which enabled them to be tightened up. The material used is an alloy of aluminium resembling, but, it is said, inferior in quality to, that known in this country as duralumin. At the largest point the framework has a diameter of 72 ft., and is of stream-line form, the bow being sensibly blunter than the stern, which, indeed, tapers off to a sharp point. The length of the vessel appears to have been 650 ft. or 680 ft., and the weight complete, with engines, fuel, guns and ammunition, is calculated at 50 tons. The hydrogen capacity was 2,000,000 cub. ft., and there were 24 ballonets, extending the whole length of the ship. The airship was built last July, and its cost is estimated by the Admiralty authorities at about a quarter of a million. To enable the crew, which consisted of 22 men, to move from one part of the ship to another, a cat-walk ran along the keel, enclosed in an arched passage. It consisted of a narrow footway, 9 in. in width and made of wood—one of the very few examples of wood construction used—and provision for ventilation was made in the shape of shafts rising to the top of the ship. In all there were four gondolas—one forward, two amidships, and one aft. The forward one constituted, as it were, the navigating bridge. It was divided into three parts. The first was set apart for the commander, and in it were concentrated the controls of the horizontal and vertical rudders at the stern (where also there were four stabilising fins to prevent rolling), the engine-room telegraphs, and the switches for the electrical release of the bombs. These last, of which 60 were carried, were arranged amidships, and the sliding door which was opened to allow them to fall can still be seen moving freely on its bearings. Behind the commander's room in the forward gondola was a cabin for the wireless operator, measuring perhaps 6 ft. by 4 ft., and behind that again an engine-room containing a 240-h.p. Maybach-Mercédès engine having six vertical cylinders. Behind the engine was a clutch, a brake, and a reducing gear, through which the power was transmitted to a propeller shaft; a generator for the wireless installation was placed in front. One similar engine was carried in each of the gondolas amidships, and three in the aft gondola, all the engines having wireless generators attached. There were thus six engines, with an aggregate power of 1,440 h.p., and six propellers. Of the latter, three were worked from the aft gondola, one being placed in the centre at a point-distant from the tail about one-fifth of the length of the ship, and the other two one on each side; two were driven from the side gondolas amidships, and the sixth was in connection with the forward gondola. To reduce air resistance a stream-line form was given to the propeller stays by the aid of a thin two or three-ply wooden casing shaped in the proper way. The amount of petrol carried was 2,000 gallons, and the speed is supposed to have been about 60 miles an hour in a still atmosphere. The armament, apart from the bombs, consisted of nine quick-firing guns. Of these two, larger than the others, were mounted on the roof, two were in the forward gondola, one each in the amidships gondolas, two in the aft gondola, and one in the tail. The lightness of the construction is shown by the fact that the huge tail, still containing the remains of the gun platform, can easily be rolled over by one man.

ELECTRON, QUANTA, AND RELATIVITY THEORIES.

To the Editor of Engineering.

Sir,—The late Professor Osborne Reynolds spent 20 years in an exhaustive research "On the sub-mechanics of the universe," and determined the criterion (Phil. Trans., 1895) for the flow of viscous fluids "which led to the recognition of the possibility of the analytical separation of the general motion of a fluid into mean varying motion displacing momentum, and relative motion without mean momentum, and this suggested the possibility that the medium of space might be granular, the grains being in relative motion and at the same time being subject to varying mean motion." He, however, failed to divide the close packed dodecahedral-cubic formation usually assumed for atomic marshalling into separate interpenetrating plena; but this is readily accomplished by considering one only of the two sets of alternate tetrahedral angles of a cube inscribed in any one atomic dodecahedral domain and thus obtaining a tetrahedral bond for every atom, which allows of relative interpenetrating motion of two plena. Now, sir, if the motion of one plenum is relative without mean momentum it must be due to the Reynolds' dilatancy within the primary or momentum plenum, this dilatancy acting separately on every atom of the relative secondary plenum. Have we not here the physical connection of the mechanics of matter in bulk with the real mechanics of the atom, the electron, and the quantum? The electron is the spiral atomic momentum of Poynting's energy vector carried by one plenum of an atomic ether from a positive to a negative centre and causing a relative motion of the interpenetrating plenum; while the quantum is the energy of a heavier atom varying with atomic weight which strikes that ether, thus producing an impulse which travels across it in straight lines as radiation, the wave-length being a function of the impulse and the atomic constitution of the ether.

It is well known that mathematicians can present a truth but are not always able to give its physical interpretation. Maxwell requires his Faraday, just as Faraday needed his Maxwell for the interpretation of his physical conception of a line of force. Osborne Reynolds presented us with a truth of which he obviously felt the great importance, but we failed to understand him because of the mathematico-physical interpretation in his work "On an Inversion of Ideas as to the Structure of the Universe."

With a partially-relative ether the physical meaning of relativity becomes clear. Also the equations for the motion of a frictionless fluid in bulk are the simplest possible, but hitherto the relative atomic motions which must occur to correlate inverse variation of speed with transverse area of fluid have been unknown. Stream lines may be resolved into two components mutually at right angles and one for each plenum.

It is admitted that the Quantum theory and the Electron theory, each separately correlating an immense number of facts within its own specialised domain, are yet in irreconcilable opposition to each other. The situation has developed precisely as foreseen by Maxwell and beautifully stated in the preface to his "Electricity and Magnetism." To bolster up the Weberian System of electrodynamics we are to-day asked to call in question the conceptions of time and space and even the Newtonian mechanics, thus sacrificing reason itself. A mathematician can scarcely write on these subjects to-day without using the word "hope." Hope implies fear: fear that the mathematico-electrical theories of matter will come crashing to the ground. Bohr's famous hydrogen atom, for instance, would not survive a graphic interpretation. Why is the British Association silent on these great subjects?

Fred G. Edwards.

33, St. Ronans-road, Sheffield, October 7, 1916.

RELATIVITY, GRAVITATION, TENSILE STRENGTH.

To the Editor of Engineering.

Sir,—The correspondence on Relativity has been somewhat ironical, not explanative. Man's brain is still in progressive structural adjustment to the finer formative inherences of matter, constituting the phenomena of his earth; his intelligence is twofold; it is not to be expected that the analytical processes of the lower mind can deal with the more subtle inherences, even the intellect Professor Bergson, in his "Introduction to Metaphysics," considers not quite adaptable for his purpose, so, in order to render intuition available he intellectualises it, and this method of his cannot but have far-reaching results. At page 58 he speaks of: "The demonstrations which have been given of the relativity of our knowledge" as being "tainted with an original vice," "Concepts with fixed outlines in order to clasp with them the reality which flows"; but (page 59) the truth is that "our intelligence can follow the opposite method. It can place itself within the mobile reality . . . can grasp it by intellectual sympathy, which we call intuition . . . in this way it will attain to fluid concepts capable of following reality in all its sinuosities, and of adopting the very movements of the inward life of things." This inward life of things is the subtle forces which sway the materials with which the engineer deals.

Involved in this procedure, necessary for "a progressive philosophy," is the solution of the riddle of the harmony between "feeling and thinking"; tacitly acknowledging that concepts, a mode of analysis, will not give one feeling, that is, one cannot argue oneself into the feeling of sympathy, the professor passes from the lower into the higher mentality, and bringing to his

aid the still higher power of intuition, he merges intellect into it; so that, accepting emotion to be a feeling mentalised, intuition becomes feeling intellectualised, and in this the professor has intuitioned an old Greek gnosis that the augoeides, or intellectual body-sheath, in its functional evolution, finally unisons a vibratory absorption in intuition.

Thus the professor intimates that intuition need not be waited for, it can be intellectually seized. Let the professor be now followed to his symbolisms of a stretched piece of india-rubber and an extended metal spring (*op. cit.*, page 13), when he treats of forces that have had to be dealt with in all materials put to use. Passing by his thesis of one's consciousness of duration, so acutely stated, which, however, I apprehend to be a *state* that, as consciousness, immortally persists independently, though co-ordinately amenable to the "pure mobility" of matter; also passing his query as to "pure mobility," the act of tension or extension yields "a more faithful image of the development of ourself in duration"; or even whether the "tension and extension" be that force which holds an iron girder in its specialised form, or be the ordinary molecular interlock; let these two last be traced to, perhaps, some useful practical concepts.

Accepting the ultimate basic forms of chemical matter to be the positive and the negative two ultimate and permanent atoms, as stated in "Occult Chemistry," whose internal many-graded circular rings of beaded (pure) force gyrate at great speed, in the one atom to the right, and in the other to the left, these two sets of many-phased streams of oppositely moving force can energise when in contact into an interlock determined by the arrangements of the particular element's molecules, and is amenable not only through its rings but also through the higher forces of "the atoms of the four higher planes which surround and interpenetrate it" to such of the earth's magnetic forces that may be harmonious thereto. Iron possesses great tensile strength, and it is not improbable that this is due to the earth's magnetic iron-quality flow being dynamically or rather harmoniously segregated in all iron deposits in the earth which magnetises every piece of iron with its current, and it is this current which may constitute the tensile strength. This hypothesis would posit that there are much less deposits, say, of lead than of iron, and that the earth's force is not particularised so far as the lead-structure be concerned, this metal being only attracted, as it were, by simple gravitation. The earth in its continuous axial revolution receives the many-graded emissive outpourings from the sun, so constituting, not only to our planet, but to each planet, a reinvigorating systolic action; the diastole is said to take a similar time—five years—and the sun's fiery purging process one year, sunspot year; each planet would, therefore, in crossing the outpouring and inpouring streams of matter, render itself subject to "planetary influences," but astrology has much to learn before it can take its place as a science.

What I have written is not said to draw polemical rejoinder but to place the subjects mentioned in perhaps a light relatively clearer.

London, S.E., October 9, 1916. A. H. B.

RESTRICTION OF OUTPUT.

To the Editor of Engineering.

Sir,—The diagnosis in your current issue of the cause of the workers' opposition to speeding-up methods mistakes, I believe, the minor for the major cause—the major cause being the idea of the lump of labour or fixed quantity of work to be done and the consequent fear of unemployment.

How deep-rooted and well-founded the last fear may be no one in a secure position can realise. I have worked on a large variety of jobs both in this country and Canada, and I am convinced that except in a few cases men would rather work to the limit of their capacity than waste time, given, however two conditions—the hours of labour must not be unduly long and the men must either feel secure of work enough to last or of another job.

There is one other point—the idling habit once acquired is hard to get rid of, and works should so be arranged that the younger generation will not acquire it. Foremen are too often indifferent as to how apprentices spend their time, oblivious of the fact that habits of indolence are being formed, and the same applies to spells of unemployment.

My contention is that a healthy man, free from anxiety, will delight to spend his strength and do as much work as he can, and it is up to employers to see that wages are sufficient to meet these ends.

I could illustrate these arguments by copious extracts from my own experience and reading, but have perhaps trespassed far enough upon your valuable space.

Yours truly,

John S. Rann.

Manchester, October 15, 1916.

THE BURSTING OF WATER-PIPES.

To The Editor of Engineering.

Sir,—In your issue of September 22 you give under the heading of "Notes" a very interesting résumé of observations on "Growth of Crystals under Pressure." So far as crystals formed in a saturated solution are concerned, I can quite imagine that such may possibly be capable of exerting a linear pressure, as probably a film of the mother liquor will be drawn into the infinitesimal space which exists at the base and also at the point of the crystal.

This film will in turn yield small crystals which will add appreciably to the height of the whole and thus exert a certain degree of pressure. Towards the end of the "Note," however, there occurs a remark which leads me to doubt if the bursting of pipes by freezing water has been properly understood. When water contained in a thin test tube of glass is frozen by immersing it in a suitable freezing mixture it will freeze solid without bursting the fragile tube. The reason for this is plain. When the water begins to freeze it is, of course, the layer of liquid next the glass which becomes solid and as crystals grow normal to their starting point a time comes when the crystals meet in the centre of the tube. Up to this point there has been an increase in bulk of say 10 per cent. as compared with the volume of the water which has become solid, but as soon as the crystals touch all growth must cease as there is no liquid between the points of contact from which new crystals may be formed. From this it is evident that the freezing of water in pipes can exert no radial pressure on the bounding surfaces. What really bursts a frozen pipe is the fact that the growth of crystals in any part of a pipe causes a displacement of water equal to about 10 per cent. of the water which has become solid. Now the displaced water must go somewhere, and accordingly it moves into the part of the pipe where there is still some liquid. The result is that a pipe always gives way at the part which is last to freeze and this I have verified over and over again experimentally. A lead pipe filled with water, made secure at the ends and wrapped round with felt in the centre for a few inches and then allowed to freeze, will inevitably burst where protected. This I think is absolute proof of the correctness of what I have tried to set forth above. Strange to say I have never met with anyone who had grasped this extremely simple solution of burst pipes. Even so eminent a man as the late Professor V. B. Lewis, lecturing at the Royal Institution, told the audience that making pipes of oval section would prevent damage.

Yours, &c.,

Geo. Rodger.

34, Oak Hill-road Sheffield, October 6, 1916.

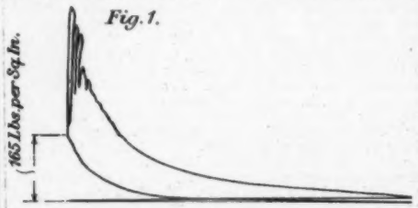
STARTING DIESEL ENGINES WITH LOW COMPRESSION.

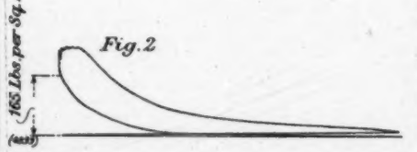
To the Editor of Engineering.

Sir,—The letter of Mr. Benton in your issue of the 13th inst. on the above subject contains many exceedingly interesting questions, and I regret that I cannot, at present, deal with more than two or three of these.

Mr. Benton has misinterpreted the indicator diagrams given in my British Association paper, published in Engineering of September 22. The diagrams in Figs. 2 and 3 are of the same general character, although the compression pressure varies from about 470 lb. in the first line of diagrams of Fig. 2 to 260 lb. pressure in the case of some of the diagrams in the second line of Fig. 2, and in Fig. 3 the compression pressure for one diagram is 220 lb. per square inch.

All the diagrams in Figs. 2 and 3 may be described as of the Otto cycle type, that is, the inflammation of the charge occurs at constant volume. The diagram shown in Fig. 5 is approximately of the form normal to the





Diesel type of engine, and the inflammation in this case takes place at approximately constant pressure. The change in form of the diagram from that shown in Fig. 2 to that shown in Fig. 5 is not due to a change in the density of the charge at the end of compression, as suggested by Mr. Benton, because, as shown in some of the diagrams in Fig. 3, the compression pressure to those diagrams is lower than for Fig. 5.

I send herewith two indicator diagrams which I have taken to-day from the Diesel engine referred to in my paper, and in both of these diagrams the compression pressure was only 165 lb. per square inch above atmospheric pressure. In Fig. 1 the inflammation took place at constant volume, whereas Fig. 2 shows only a comparatively slight increase in pressure during inflammation. Neither of these diagrams gives any indication that the lower limit of compression pressure to effect self-ignition has been approached in these cases, and, as stated in my British Association paper, I think that it should be as easy "to obtain ignition temperature by compression to two atmospheres as it is to obtain it in the ordinary way by compression to 34 atmospheres; but I have not yet made the experiment with such low compression pressure."

According to my view of the matter Mr. Benton is in error in assuming that reduction in "the weight of working fluid" must lead to increase in the rate of cooling during compression. If the mass of gas is reduced to one-half, while its temperature remains constant the number of molecules of the gas which will collide per second with the walls of the enclosure will be reduced to approximately one-half, and, therefore, the rate of loss of heat will also be reduced to approximately one-half. The reduction in the density of the gas will increase the average length of the free path of the molecules, but this will not greatly affect the result. The important matter in the above case is not the area of cooling surface per unit mass, but the area of cooling surface per unit volume, and this latter ratio remained constant in my experiments. I may add that the paper which I actually read before the British Association was only a small section of a much larger paper which I had prepared. The publication of the much larger section was deferred, for reasons not unconnected with the war. This statement will indicate why fuller data were not given.

Yours faithfully,

W. H. Watkinson.

OIL-ENGINE NOMENCLATURE.

To the Editor of Engineering.

Sir,—With reference to your correspondent Mr. Hughes's letter, published in your issue of June 30 last, page 622, in which he refers to Dr. Clerk discussing, in 1905, experiments carried out by him in injecting gas into compressed air as early as 1887, I have the keenest regard for the good work done by Dr. Clerk on the gas engine, but with the absence of any reference in either Dr. Clerk's text-book "Gas and Oil Engines," 1896, or Clerk and Burl's text-book, 1912, as to the practical purpose of any such experiments, or indeed any reference to them at all, it is very evident that even Dr. Clerk did not consider the matter of great importance.

To better qualify my letter in your issue of June 23 I am sending two illustrations* of the earliest "Akroyd" oil engines, together with indicator diagrams, &c. No. 3 was taken by Professor Robinson at Bletchley Iron Works, Bletchley, Bucks, in 1891, the others by myself.

I am pleased to note from your advertising columns a growing disclination by British makers to the term "semi-Diesel," and if my correspondence has been instrumental in any way in bringing this about I shall be repaid.

It certainly does seem an absurdity that we should "semi" anything when the "whole thing" is purely British.

I thank you for your past courtesy.

Yours faithfully,

Herbert Akroyd Stuart, M.I.M.E.

Trade of India Within the Empire.—The Secretary of State for India has authorised the Indian Committee of the Imperial Institute to inquire into and report on the possibilities of further extending the industrial and commercial utilisation of Indian raw materials in this country and elsewhere in the Empire.

Engineer-in-Chief of the Glasgow and South-Western Railway.—Mr. William Melville, who has been for 25 years the engineer-in-chief of the Glasgow and South-Western Railway, is retiring from active work at the end of the current month, and is to be succeeded by Mr. Thomas Keeling, who has been in the service of the company since 1882 and has acted as chief assistant for a number of years. Mr. Melville has throughout his professional career been associated almost exclusively with railway engineering in Scotland, and has done much important work for all the three principal railways. He was chief assistant engineer in Glasgow for the North British Railway, and amongst his important works was engaged upon the construction of the Queen Street passenger and goods station and grain store. He built the Craigendoran Railway and Pier near Helensburgh, and it is a remarkable coincidence that in later years he also was responsible for the Gourock Railway and Pier for the Caledonian Railway, and still later for the great improvements effected at the Princes Pier of the Glasgow and South-Western Railway, so that all three river terminals for passenger traffic of the three Scotch companies are largely the work of Mr. Melville. He was for many years chief assistant engineer for the Caledonian Railway. Among other works he extended the Caledonian lines in the City of Glasgow, from Dalmarnock to St. Rollox, and widened the line from the central station across the River Clyde. While with the late Mr. Graham, too, he prepared a number of working drawings for important lines, some of which have since been carried out. On almost every line of the Glasgow and South-Western Railway he has effected improvements during his 25 years' work, the most important perhaps being the construction of the new viaduct carrying four lines of railway from St. Enoch's Station across the River Clyde. The bridge varies in spans from 60 to 130 ft., and the construction of the approaches required the demolition of considerable street property. St. Enoch's Station was also extended, and, as we have said, a new station at Princes Pier was also made. He also reconstructed the Largs Pier, and did considerable harbour work at Troon and other commercial ports served by the Glasgow and South-Western Railway. He constructed an esplanade on the foreshore at Ayr. The geographical mileage of the South-Western Railway in 1891 was 319, and is now 447, 74 miles having been constructed. In the case of 29 miles widening has been effected. The mileage of lines purchased was 54.

* [We do not consider it necessary to reproduce these illustrations.—Ed. E.]

THERMO-ELECTRIC MEASUREMENT OF THE CRITICAL RANGES OF PURE IRON.*

By GEORGE K. BURGESS, Sc. D., and H. SCOTT (Bureau of Standards, Washington).

Introduction.—There have been a number of thermo-electric observations made over the critical ranges of iron, A2 and A3, using an iron wire as one element of a thermocouple and usually a platinum or copper wire as the other.(1) These observations possess the disadvantage of giving the total electromotive force developed between the cold junction kept at ordinary temperatures and the hot junction immersed in the heated region of a furnace; there may thus be ambiguity of superposition of thermo-electric effects along the iron wire. Messrs. Boudouard and Le Chatelier endeavoured to overcome this difficulty, in the case of certain steels,(2) by using short bars to the ends of which platinum wires were attached, but they were unable to get very satisfactory observations due to temperature irregularities, nor did they work with pure iron. Dr. Benedicks has recently devised a method(3) which, as described, has the disadvantages above noted of ambiguity, and in addition seems to require for the detection of a transformation point that it exist at different temperatures on heating and on cooling.

It has been demonstrated, however, that the thermal effect for the transformation A2 occurs at the identical temperature 768 deg. C. on heating and cooling(4) and the same might be expected to be true for the thermo-electric effect. Benedicks was unable to detect any thermo-electric effect at A2.

The Method.—With the object of furnishing a more exact experimental basis on which to construct an adequate theory of the iron transformations, it seemed desirable to investigate the thermo-electric phenomena of pure iron more accurately than has hitherto been done. In the following experiments we have used a modification of the method of Le Chatelier giving the thermo-electric power directly, but have succeeded in eliminating the uncertainties of temperature control and distribution; have carried out the experiments *in vacuo*, and have used iron of exceptional purity. The observations extend over the range 0 deg. to 1,000 deg. C., and the thermo-electric characteristics of the transformations A2 and A3 have been determined with considerable accuracy. It has been found possible to measure the thermo-electric power (dE/dt) of iron against platinum for intervals of 2 deg. up to a temperature of 1,000 deg. C., from observations in which the fall of temperature along the iron remained quite constant, usually less than 10 deg. C.

The Materials.—The iron used in these experiments was from an electrolytic deposit which had been subsequently melted *in vacuo* and was of an exceptionally high degree of purity, 99.968 per cent. iron, being from Sample F4 of Scientific Paper No. 213. Its analysis gave: Carbon, 0.009 per cent.; sulphur, 0.009 per cent.; phosphorus, 0.001 per cent.; silicon, 0.006 per cent.; manganese, 0.001 per cent.; copper, 0.006 per cent. This was drawn through sapphire dies into wire of 0.05 cm. diameter. The platinum of the thermocouples, and also against which the thermo-electric power of iron was determined, was from Johnson and Matthey. The thermo-electric force developed by this platinum against the purest samples of normal Heraeus thermocouple platinum was determined at 1,100 deg. C.(5) The difference in thermo-electric power was less than 0.1 microvolt, except for one series with a contaminated platinum couple.

The Apparatus.—The apparatus is essentially the same as that used for the thermal study of the critical ranges of iron described in detail in Scientific Paper No. 213 of the Bureau of Standards. Its principal characteristics are a double-walled electric resistance furnace of 60 cm. length in which a vacuum is maintained; an automatically controlled A.C. current supply for heating and cooling the furnace uniformly at any desired rate; a drum chronograph for recording times of observation to 0.1 second; a potentiometer reading to 0.1 microvolt; two galvanometers and a suitable commutator, by means of which temperatures and temperature differences may be measured to 0.01 deg. C. and electromotive forces of the iron-platinum couple to 0.07 microvolt.

Fig. 1. EXPERIMENTAL ARRANGEMENT.

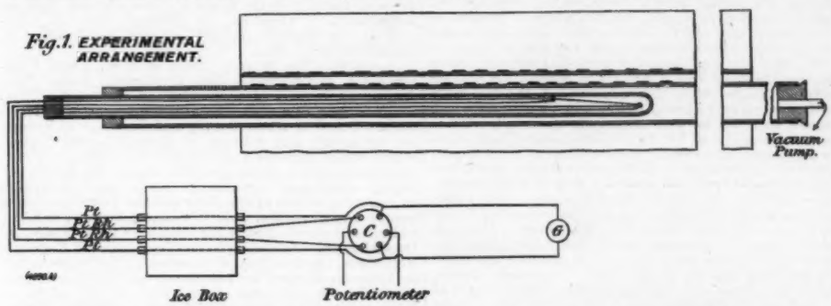


Fig. 2. OBSERVATIONS WITH IRON-PLATINUM COUPLES.

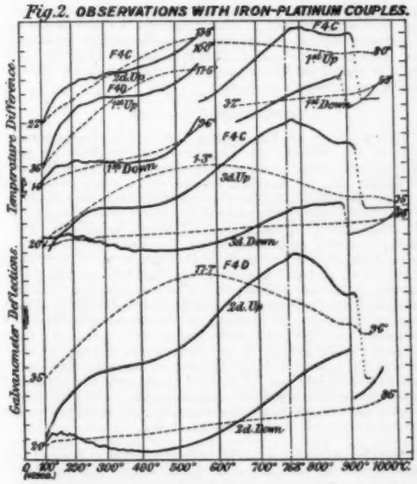
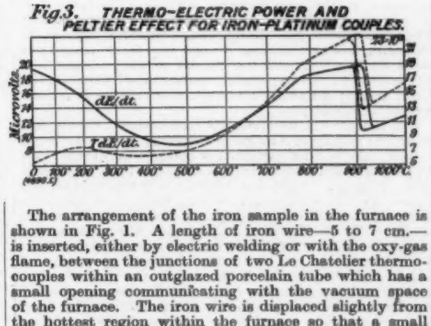


Fig. 3. THERMO-ELECTRIC POWER AND PELTIER EFFECT FOR IRON-PLATINUM COUPLES.



The arrangement of the iron sample in the furnace is shown in Fig. 1. A length of iron wire—5 to 7 cm.—is inserted, either by electric welding or with the oxy-gas flame, between the junctions of two Le Chatelier thermo-couples within an outglazed porcelain tube which has a small opening communicating with the vacuum space of the furnace. The iron wire is displaced slightly from the hottest region within the furnace so that a small temperature difference will always exist between the two ends of the wire; and care is taken that one end—and not an intermediate region of the wire—is its hottest part.

Observational Method.—With two observers, simultaneous observations were taken at 2 deg. intervals of: (1) the temperature of one end of the iron wire by means of a thermocouple and potentiometer (see Fig. 1), and (2) the deflection of a galvanometer (G) connected across the platinum wires having the iron in the circuit; every 10 deg. the temperature of the other end of the iron wire was taken with the second thermocouple. The instant of each observation was recorded on the chronograph. The true electromotive forces of the iron-platinum couple caused by the temperature drop along the iron wire were then calculated (from 2), correction being made for the quality of platinum (negligible, except for one series) and resistance of circuit and galvanometer. This electromotive force, divided by the corresponding difference in temperature, *i.e.*, between the two ends of the iron wire (2 deg. to 3 deg.), was taken as the true thermo-electric power of the iron-platinum couple at the temperature of the hot end of the iron wire. A few observations were also taken around 0 deg. C. and 100 deg. C. by the usual method of using an iron-platinum thermocouple having wires passing from the region of variable temperature to a constant temperature, ice or steam.

The thermocouples were carefully intercompared and calibrated several times during the experiments, and several calibrations were taken of the galvanometer (G) and scale giving electromotive forces across the iron-platinum couple. Two sets of thermocouples were used, and four lengths of iron wire, all from the same analysed sample. The rate of heating or cooling was usually of the same order of magnitude and was about 0.1 deg./sec.

The Experimental Results.—These are given in Fig. 2. For the dotted curves, the ordinates are proportional to the observed values of galvanometer deflections (G of Fig. 1), which again are approximately proportional to the thermo-electric power of the iron-platinum couple. The abscissæ are temperatures. Each dot represents an observation on the respective heating or cooling curve marked "up" or "down." The dashed curves represent the differences in temperature between the two ends of the iron wire for the adjacent heating or cooling curve.

It is seen that, for the several series, A3 is indicated by a marked discontinuity in thermo-electric power, as already noted by Benedicks and others for the electromotive force-temperature curve. As would be expected from the thermal(4) and electrical(6) observations, Ac3 always occurs at a somewhat higher temperature than Ar3.

The A2 transformation manifests itself, in all cases, by an abrupt change in direction of the curve representing thermo-electric power against temperature. As shown, this is slightly above 768 deg. C., the maximum of the thermal transformation. The actual location of the break in the thermo-electric curve appears to be related to the length of iron wire and the temperature distribution. The thermal transformation—absorption or evolution of heat—is also sharply marked on the curves as a protuberance or dent at exactly 768 deg. C. The fact that this thermal phenomenon is always recorded, even at the junction of wires only 0.05 cm. in diameter, is further evidence of the sensitiveness of the method of measurement and of the persistence of A2 to assert itself when given an opportunity.

The lower portions of the curves below 400 deg. C. are less satisfactory than at higher temperatures, and for several reasons. There is greater difficulty in obtaining uniformity of temperature distribution, greater sensitiveness to draughts, and at times there were galvanometer and pump troubles; also the heating currents below 400 deg. C., which protect thermally the sample, were almost if not quite zero.

It will be noted that for all the curves, the A1 transformation at about 700 deg. C., due to the presence of carbon, is absent. For iron containing as little as 0.1 per cent. carbon, this A1 point is, however, very marked, and was obtained accidentally by the authors when oil vapour from the vacuum pump got into a sample of pure iron. There appears to be no permanent change in direction of the thermo-electric power curve at A1, but this transformation produces a jagged swinging back and forth during its progress. The authors expect to be able to publish shortly an account of the thermo-electric properties of carbon steels.

TABLE I.—*Thermo-Electric Power of Iron Against Platinum.*

Temperature. Centigrade. t.	Microvolts per Degree. dE/dt.		Peltier Effect. $T\,dE/dt$.	
0	19.5		5,320	
100	18.1		6,750	
200	15.4		7,280	
300	11.7		6,700	
400	9.5		6,390	
500	9.1		7,030	
600	10.8		9,430	
700	14.3		13,910	
775	18.1		18,980	
800	18.4		19,740	
880	19.4		22,350	
	Heating.	Cooling.	Heating.	Cooling.
900	19.7	17.5	23,100	20,510
910	19.4	10.8	22,940	12,770
920	16.6	10.9	19,800	13,000
930	11.4	11.1	13,710	13,350
1,000	12.6		16,030	

In Table I and Fig. 3 are shown the true thermo-electric power (dE/dt) *versus* temperature between 0 deg. and 1,000 deg. C. of the iron-platinum couple, being the most probable values computed from all the series of observations shown in Fig. 2, after all corrections are applied. The Peltier effect, $T\,dE/dt$, or the product of the absolute temperature and thermo-electric power, is also shown.

Summary and Conclusions.—There is described a sensitive method for the measurement of the change of true thermo-electric power with temperature by means of which observations may be taken *in vacuo* at intervals of degrees. The thermo-electric power of the couple iron-platinum has been determined for the temperature range 0 deg. to 1,000 deg. C., using iron of 99.968 per cent. purity.

The A3 transformation in iron is indicated by a marked discontinuity, Ac3 being always above Ar3. They are located at the same temperatures, as closely as could be desired by the thermal, crystallographic, magnetic, electrical resistance, dilatational, and thermo-electric methods, Ar3 just below 900 deg. C. and Ac3 slightly above 910 deg. C. These physical discontinuities are apparently all a measure of the same transformation which it is generally agreed to call "allotropic," and which appears to delimit two phases in the iron.

At A2 the thermo-electric power-temperature curve has a break, or change in direction; and the other physical properties, except crystallographic change, which has not been detected at A2, appear to undergo abrupt but slight modification—except for the magnetic change, which is relatively enormous here.

As before stated with reference to the electrical resistance change (6), it is here again shown, this time for the thermo-electric effect, that the A2 and A3 transformations are essentially different in kind, but nevertheless both have a distinct physical existence; or in other words, A2 and A3 are critical points that properly may be said to delimit α, β and γ iron. There appears to be no break or discontinuity in the thermo-electric properties of iron between 0 deg. and 768 deg.; the actual shape of the thermo-electric power curve is, of course, contributed to by both the iron and the platinum.

At about 880 deg. C., in the β range, there appears to be a slight discontinuity in thermo-electric properties of iron. A break in the β region was first claimed by Weiss for the magnetic properties, is also noticed in the dilatation curves of Benedicks, and Burgess and Crowe called attention to it in their thermal study. The

* Paper contributed to the autumn meeting in London, September 21–22, 1916.

(1) This and succeeding numerals allude to "references" overleaf.

existence and meaning of this phenomenon are, however, too uncertain to describe them with positiveness.

References.

(1) Dewar and Fleming, *Philosophical Magazine*, 1895, IV, vol. xl, page 95; Harrison, *Philosophical Magazine*, 1902, VI, vol. iii, page 177; Broniewski, *Comptes Rendus*, 1913, vol. clvi, pages 699, 1983.
(2) Boudouard, *Revue de Métallurgie*, 1904, vol. i, page 80; Le Chatelier, *ibid.*, page 134; *Comptes Rendus*, vol. cii.
(3) Benedicks, *Comptes Rendus*, 1916, vol. clxii, page 297; *Journal of the Iron and Steel Institute*, 1916, No. 1.
(4) Burgess and Crowe, *Bureau of Standards Scientific Paper No.* 13, *Bulletin*, 1914, vol. x, page 315.
(5) Burgess and Sale, *Bureau of Standards Scientific Paper No.* 254, *Bulletin*, 1915, vol. xii, page 289.
(6) Burgess and Kellberg, *Bureau of Standards Scientific Paper No.* 236, *Bulletin*, 1914, vol. xi, page 457.

EXTENT AND PHYSICAL CHARACTERS OF NORFOLK OIL-SHALES.

Mr. William Forbes-Leslie, M.B., F.G.S., read a paper on the Norfolk Oil-Shales at a meeting on Tuesday, 17th inst., of the Institution of Petroleum Technologists. After reviewing the history of oilfields, he dealt at great length with the geology of English shale-fields, and particularly those of the Norfolk shales. The author said there is little doubt that a large oil-shale basin of Kimmeridge time existed in Norfolk. The evidence for such belief rests upon an analysis of the structure of the east of England when brought into alignment with known tectonic conditions within the area. Its geographical extent has not yet been completely demonstrated, although its visible geological features have been traced for many miles north and south and for considerable distances on the dip. The possibility of the Kimmeridge series being cut off against the edge of the chalk has not been lost sight of, but all research work in this direction goes to prove that the Kimmeridge beds dip underneath the chalk. No signs of faulting, such as cuts the Kimmeridge beds and brings them against the chalk at Ridgeway, in Dorset, can be observed in the eastern section of the Wormegay basin. The boring at Holkham, 743 ft. deep, is said to have terminated in Kimmeridge clay, although another version makes it terminate in Lower Greensand. Nevertheless, adjacent and available data lead to a belief in the permanence of the Kimmeridge beds beneath and seaward of the chalk shoreline at Holkham and Hunstanton. With a proved thickness of 6 ft. of oil-shale in Smith's series, and 6 ft. in the Puny Drain series, or a total of 12 ft., every acre of ground should yield something like 24,000 tons of shale, and half a square mile may be considered as providing for a 1,000-ton output per day for 20 years. It is obvious that the oil contents of the Norfolk end of the Kimmeridge outcrop will add very considerably to the oil resources of the United Kingdom. The whole question of the English Kimmeridge measures demands investigation.

As to chemical composition, he said when the shale is shaken up with ether that it is possible to recover as much as 1 per cent. of oil, whereas when shaken up with carbon disulphide the shale yields only 0.25 per cent. A number of analyses have been made of the Norfolk oil-shale during the progress of research work undertaken on the northern section of the outcrop. It has been found that the average volatile content in the two series is remarkably constant. Three analyses may be given as examples of the relative value of the two series.

	Smith's Series.	Puny Drain Series.	
Moisture	9.8	8.0	4.1
Volatile organic matter	35.1	31.7	37.1*
Fixed carbon	15.3	16.3	12.0
Ash	39.8	44.0	46.8

The oil obtained is golden black in colour, with a purplish tint on reflected lights. The oil is very fluid, running almost like water, despite the fact that its specific gravity is as high as 0.942 to 0.960. In this respect it differs from the Scotch shale oil, which is dark green in colour, with a specific gravity of 0.860 to 0.890, and is very viscous, with a settling point of about 32 deg. C. Norfolk shale oil differs likewise from oil derived from the Dorset-Kimmeridge series, both in its colour and in its viscosity.

The specific gravity of the motor spirit or petrol obtained from redistillation of the oil is 0.855, with a low flash point. Scotch shale naphtha has a specific gravity of 0.734. Bulk tests carried out on Puny Drain shales, both in the field work erected near the outcrop, and in works under the supervision of engineers appointed by financial interests, gave highly satisfactory results. The yield of oil on a commercial basis was 40 gallons to the ton, the nitrogen content was about 1 per cent., and the yield of sulphate of ammonia was 66 lb. per ton; while there were obtained 25,000 cub. ft. per ton of dry gas possessing highly illuminating properties. Sulphur contents were as high as 6.4 per cent. The oil obtained on these bulk tests had a high specific gravity, namely, 0.942 to 0.960, was very fluid, and yielded on distillation:—

Fractionation up to—	
100 deg. C.	3.8
100 deg. to 170 deg. C. ...	5.7
170 deg. to 245 deg. C. ...	19.2
245 deg. to 310 deg. C. ...	39.2
Water	0.8
Pitch and loss	31.5
0 deg. to 185 deg. C.	23.3
185 deg. to 250 deg. C.	24.6
250 deg. to 300 deg. C.	20.8
Above 300 deg. C. by difference ...	31.3

In the field trials, fractionation of the oil gave results recorded in the next table.

The yield of fractions coming within the limits of the motor spirit series is considerable, and of the utmost importance. In addition, the oil yields from 3 to 4 per cent. of bases extracted by weak acids, 3 to 4 per cent. of crude phenols, cresols, &c., 3 to 4 per cent. benzol and toluol. The main interests of these bulk trials is the extremely low temperature at which the shales yield a big proportion of their oil contents, and that the residues contain 20 to 27 per cent. of carbon, fixed and unfixed. Only one factor may be conceived to affect the value of the deposits, and that is the quantity of the sulphur contents, which vary from 4.32 to 7.8 per cent.

* Including combined water and organic sulphur.

THE ELECTRICAL INDUSTRY OF THE CENTRAL POWERS.

Pending the further commercial and industrial consolidation of Germany and Austria, and perhaps their allies, which is bound to result from the war, and for which preparations have already been going on for some time, it is of interest to see the extent to which co-operation already exists, thanks to German enterprise. Perhaps the doings in the electrical industry are the most instructive, evidencing what it has been possible to do without the tariff facilities and probable kartel arrangements which in due course are sure to ensue.

The firm of Siemens and Halske had already, for a considerable time, had a branch in Vienna for smaller electrical articles when they constructed the two large continuous-current central stations in Vienna, for which purpose their works were materially extended. When the amalgamation of Siemens and Schuckert took place the movement extended to Austria as far as the Austrian Schuckert undertaking was concerned, which, again, had been developed from the Austrian firm of Kremenezky, Mayer and Co. By-and-by the Leopoldau cable works were absorbed, a limited company was formed in Budapest, and a factory erected in Pressburg. Although Austrian capital preponderates in this undertaking, the German mother company exercises a material influence. The business spheres of the three companies—Berlin, Vienna and Budapest—are stringently defined, so that no clashing of interests can occur; thus the Vienna company works the Balkans, with the exception of Roumania, and the Levant, but must not export to any other country. In production, constructive work, propaganda and financial doings the three companies assist each other, and the results of experiments and invention and the experience gained in all parts of the world benefit all three concerns, although each retains perfect independence.

The Allgemeine Elektricitäts Gesellschaft, Berlin, has gained its footing in Austria in a different way. To begin with it only had an installation concern in Vienna, and its products were sold through a special firm, registered as a company. After the Allgemeine's fusion with the Union Electric Company, Berlin, they took over the Austrian Union Electric Company, founded by Germans, jointly with the Union Bank, Vienna, which expansion meant not only a firm basis for future extension within Austria, but also an up-to-date footing, by means of which the Allgemeine Elektricitäts Gesellschaft was enabled to counteract or neutralise the increased tariff on electro-technical products, which increase in duty to a great extent was directed against the competition from this very company. Through its connection with a large financial concern the Austrian Allgemeine entered into close relationship with important industrial concerns, and speedily attained to a position in Austria corresponding with the mother company's position in its own country. In spite of the bulk of the capital being Austrian, there is the closest relation between the Vienna and the Berlin undertaking, and the advantages of joint working methods, &c., already referred to in connection with the Siemens concern, have here manifested themselves in the most satisfactory manner.

The third large German electric firm, the Bergmann Electricity Works, has also for years paid much attention to the Austro-Hungarian market. As a commencement the Bergmann concern sold their specialities, insulation tubes, installation materials and machinery, through representatives in Vienna and Budapest; but to avoid being hampered in its movements by the increased duty, already referred to, it was found expedient to erect a large factory within the Austrian Empire, at Bodenbach, cables and wires being added to the articles mentioned above. The Bodenbach concern works, through numerous branches, the whole of the monarchy, maintaining the same close connection with the mother undertaking as the two large concerns already mentioned.

It is not, however, only these three world-firms which, naturally enough, have secured a safe footing in Austria-Hungary, but firms whose manufacture is confined to specialities have founded branches and works in Austria. Felten and Guillaume, Mühlheim, to mention one example, have followed the plan of building up their Austrian business on the basis of an already existing factory, and by securing the business and personal connections of this factory have disposed of unwelcome competition. After 10 years' working as a private firm, the concern was turned into a limited company, iron and steel works were acquired, and a daughter company formed in Hungary. The German mother firm has maintained its close connection with the Austrian undertaking and holds the premier place on the board.

In the accumulator branch there is the closest co-operation between the parent concern, the Accumulator Company at Hagen, and the Austro-Hungarian concern, which by degrees has bought up almost all competing firms in the country and installed their manufacture in the works of a previous competitor, the Hirschwang firm. The Austrian company also works Roumania through a branch in Bukarest.

In the meter industry the Elektra-apparatus Company belongs to the Aron concern, the Isaria Elektro Company has been founded by the Isaria Company in Munich, and the Danubia Company has a sister company in Strassburg.

As regards telephones, the Telephone Fabrik Company (formerly of Berlin) holds the chief representation for the well-known Hanover house, and the chief management of the entire undertaking, to which also an Austrian factory has been connected, is domiciled in Vienna. The other large concern, the United Telephone and Telegraph Works, Czeija, Niszl and Co., Vienna, is the outcome of an amalgamation of several Vienna firms and works in close connecton with an important German firm; here, too, technical co-operation and limitation of selling spheres have been in force for years.

In the incandescent lamp industry matters are different, inasmuch as Austria, thanks to the international syndicates, has been allowed, undisturbed, to supply the home market.

COLONIAL ENGINEERING PROJECTS.

We give below a few data on Colonial engineering projects, taken from the *Board of Trade Journal*. Further information on these can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, E.C.

Australia.—The Sydney Office of H.M. Trade Commissioner in Australia has forwarded, under date August 16, a copy of a specification and tender form, &c., in connection with a call for tenders by the Metropolitan Board of Water Supply and Sewerage at Sydney for the supply and delivery at Ryde Pumping Station of two steam turbines and two sets of condensing plant, comprising steam turbine, surface condenser, kinetic air pump, centrifugal circulating pump and condensate pump. The offices of the Metropolitan Board of Water Supply and Sewerage, 341, Pitt-street, Sydney, N.S.W., will receive sealed tenders for the above up to 2 p.m. on December 16. According to the *Commonwealth Engineer*, Melbourne, the Queensland Government has approved of an irrigation scheme for Inkerman, near Bowen, to cost 131,000*l*. The estimates of the scheme are as follow:—Preliminary work (surveys and wells), 16,500*l*.; lifting appliances, 30,000*l*.; power station, 39,800*l*.; distributing network, 38,400*l*.; contingencies, on the basis of 5 per cent., 6,235*l*. It appears from the same source that the Tumut Municipality, N.S.W., has decided to take steps to instal an electric supply plant and also a gravitation water supply system.

The Society of Engineers.—At the ordinary meeting of the Society of Engineers, to be held at the apartments of the Geological Society, Burlington House, Piccadilly, W., on Monday, December 11, commencing at 3 p.m., two papers will be presented for discussion dealing with the sources of minerals and mineral ores required in the engineering industry of the United Kingdom. The first paper will be presented by Professor W. G. Fearnsides, M.A., Sorby Professor of Geology at the University of Sheffield, and will deal with the minerals required by the iron and steel industries. The second paper will be presented by Professor C. G. Cullis, D.Sc., M.I.M.M., Professor of Economic Mineralogy at the Imperial College of Science, and will deal with non-ferrous ores. As the subject for discussion is of exceptional interest at the present time, and a large number of eminent engineers and metallurgists will be invited to attend, the Council have decided to throw the meeting open to the public by tickets which may be obtained (gratis) on application to the Secretary, 17, Victoria-street, S.W.

The Gilbert Club.—The Gilbert Club was formed in 1889, under the presidency of the late Lord Kelvin (then Sir William Thomson) with the object of publishing a translation of William Gilbert's "De Magnete" and, further, of gathering all the available information about Gilbert's life and work. The work was translated by the combined efforts of several scientific men and classical scholars, and was issued in sumptuous style in the early part of this century. It was, as far as possible, a *replica* of the original edition of the work, on similar paper, and with type reproduced from an ancient matrix. Copies were distributed to the members of the club, and a certain number were sold to the public. There still remain 34 copies, while the hon. treasurer has a balance in hand of rather less than 40*l*. It is felt that the time has come when the club should be wound up and the balance dealt with in some way, and to facilitate this a meeting was held last Wednesday at the Society of Arts to take the opinion of the members, or of such of them as survive and can be found. It was suggested that an effort should be made to sell the remaining copies, which become more and more valuable from their rarity, quite apart from their intrinsic interest, and then to use the money as a nucleus for the foundation of a scholarship at the Royal Grammar School at Colchester. As 100*l*. or so will not go far in founding a university scholarship, it was also suggested that if after a certain period, say, five or ten years, the scheme had not become practicable by much larger sums being raised, the money in hand should be paid over to the Institute of Electrical Engineers for some definite object, such as the benevolent fund. If this plan be adopted the affairs of the club will finally be wound up in one way or the other. The necessary resolutions will be proposed at a later meeting, which will probably be called in January by the hon. secretary, Mr. Conrad W. Cooke, of Langland Gardens, Hampstead, N.W.

HIGH-PRESSURE AIR-COMPRESSORS.*

By Joseph M. Ford.

Compressed air at high pressure is becoming an increasingly important medium in modern engineering practice and in naval warfare. The following paper deals with the machines which produce high-pressure air, leaving on one side the question of power transmission by compressed air. In passing, the principal advantages of this system of transmission—in the facility with which energy can be stored, the almost unlimited rate at which accumulated energy may be converted into useful work, and the fact that, apart from the loss of efficiency involved, leakage cannot cause any serious consequence (compare electric and hydraulic systems of power storage) —may be mentioned, and are seen to be considerable.

Applications of High-Pressure Air.

Torpedoes.—One of the best instances of the adoption of high-pressure air as a medium for power storage is to be found in torpedo work. The torpedo is launched from the tube by means of compressed air, usually stored at a high pressure, and when in the water is propelled by an engine deriving most of its power from compressed air.

Starting of Internal Combustion Engines.—The starting of prime movers of the internal combustion type of considerable size is almost invariably carried out by compressed air, except perhaps in very special cases, such as some generating sets, where the dynamo can be "motored."

Reversing Marine Oil Engines.—In marine work, with engines of the Diesel and other types, reversing and manœuvring involve the displacement of a considerable amount of the valve-driving mechanism—most conveniently accomplished by compressed air.

Fuel Injection with Diesel Engines.—One of the principal applications, however, is in Diesel engine work, where compressed air is used, not as a medium for energy storage in the usually accepted sense of the term, but to inject the liquid fuel into the working cylinders against the compression pressure of about 30 atmospheres (430 lb. per square inch).

Auxiliaries in Diesel-Engined Ships.—In some oil-engined ships high-pressure air is used for driving some auxiliaries, such as steering gear, main engine turning gear, small pumps, &c., and in submarines the air is used, among other things, for blowing the ballast tanks.

Pressures Adopted in Practice.

Within limits, the lower the working pressure of the air, the higher the efficiency, but exigencies of space and weight may demand that the storage reservoirs shall occupy minimum space, in which case, for a given amount of energy stored, the pressure should be as high as possible—particularly, for instance, in a torpedo, where the dimensions and weight of power plant must be cut down to a minimum, almost irrespective of cost, and the pressures employed range accordingly from 2,000 to 4,000 lb. per square inch.

Starting and Reversing Internal Combustion Engines.—With internal combustion engines the design and type determine the pressure of the starting air. For example, gas, paraffin and petrol engines are frequently started with air at 100 to 300 lb. per square inch. With Diesel engines of the four-cycle type about 300 lb. per square inch usually suffices, whereas in engines of the two-stroke type the pressure may be as high as 1,000 lb. per square inch. One of the disadvantages of using high pressures in this connection is that when starting a refractory engine—which does not readily pick up on fuel—the continued expansion of high-pressure air in the working cylinders lowers the temperature to such an extent that the heat of compression is insufficient to ignite the injected oil. With reversing mechanism the obvious advantage accruing from the use of air at high pressures is that the dimensions of the servo-motors may be kept within small limits, which is of moment in some installations, although the higher the pressure the more difficult it is to maintain tightness and the better must be the fits, &c.

* Paper read before the Greenock Association of Shipbuilders and Engineers.

Fuel Injection with Diesel Engines.—For fuel injection the air pressure is determined by the theoretical cycle of operations in the working cylinder, and varies from 600 to 900, and in extreme cases even to 1,000 lb. per square inch, according to the particular design of engine, kind of fuel and load.

Auxiliaries.—The question of driving auxiliaries by compressed air is a vexed one. Unless the air can be heated before expansion in the engine cylinder, low initial pressures should be used. With high pressures the re-expansion lowers the air temperature so much, due to work being done by the air, that snow forms and interferes with the working of the valves, throttle passages, &c. Fig. 1 shows the theoretical efficiency of a transmission system when there is no preheating. The mechanical efficiency of the engine at the different pressures is assumed to be the same as that of the compressor at the corresponding pressures. The "air efficiency" is the ratio of work obtained from the air in the engine to the work done on the air in the compressor. A considerable gain in efficiency may be effected if the air can be heated before use, especially when this can be inexpensively done—*e.g.*, by the exhaust gases of an internal combustion engine. The advantages of this system are nullified, more or less according to particular circumstances, by the low efficiency. Practical considerations, such as the question of leaks, &c., favour low pressures, whereas such considerations as the size of pipes, cylinders and storage generally demand a compromise, although it is cheaper to make an efficient large low-pressure reservoir than a satisfactory small high-pressure one.

Simple Air Compression.

By way of introduction a few points on the elementary thermodynamical aspect of air compression may assist towards the understanding of the special features of high-pressure compressors. If air be compressed isothermally, a certain amount of work has to be done —see Fig. 2, giving a theoretical indicator diagram for a machine delivering air at 80 lb. per square inch. With isothermal compression the work required is represented by the area ABED. If the compression be adiabatic, then the additional work required is represented by the area BGE, from which it will be seen that the aim should be to secure isothermal compression, that is, to prevent increase of the temperature of the air during compression. Not only from the point of view of power absorbed should the temperature rise be small, but also for mechanical reasons, as later explained.

The index "n" in the standard equation $PV^n = C$ is in some ways a measure of the amount of heat abstracted during compression. With adiabatic compression its value for diatomic gases such as air is 1.41, and with isothermal compression its value is unity. In actual practice the amount of heat removed by a water-jacket on an air compressor cylinder is such that its value lies between about 1.28 and 1.35, the latter value being more applicable to large high-speed machines.

The line BF on Fig. 2 represents compression according to the law

$$PV^{1.3} = \text{constant}.$$

This means that the saving in work effected by cooling the air during compression is represented by the area BGF. Moreover, the reduction in the final delivery temperature is to be noted.

The diagram in Fig. 3 is the $\theta\ \phi$ diagram corresponding to Fig. 2. This shows rather more clearly the difference in the work required and temperature attained by compressing under the various conditions. The figure is self-explanatory.

Compression in Stages.

When pressures of 1,000 lb. per square inch and over are required, the temperatures attained by single-stage compression would be extremely high. If lubricating oil could be eliminated from the problem, careful design might succeed in producing a compressor that would stand the stresses set up by the high temperatures.

Lubricating oil burns in air at such temperatures, with the result that the pistons would become carbonised, the valves clogged and the pipes scoted-up. In addition, high temperatures have deleterious effects on tempered steel valves and springs. With large high-speed machines the temperature, coupled with the peculiar fatigue phenomenon, makes it wellnigh impossible to get satisfactory working with temperatures higher than those consequent upon about six compressions in one stage.

If the excessive work of compression and high temperatures are to be avoided, the heat must be abstracted from the air in the period between the start of compression and the commencement of delivery. Jacketing alone is insufficient. The method that suggests itself is to compress the air a small amount, then withdraw it from the cylinder, cool it to atmospheric temperature, and return it to the cylinder. Next, move the piston further to compress the air still more, and repeat the cooling process, and so on, until the required pressure is attained. This is virtually the method adopted in practice, except that in lieu of carrying out the whole process in a single cylinder, one cylinder is devoted to each stage of compression, and between each stage the air is passed through an intercooler to reduce its temperature to the initial atmospheric temperature. The saving in work effected by stage compression with intercooling is shown in Figs. 4 and 5. The PV diagram, Fig. 4, has been drawn for a three-stage machine compressing to 1,000 lb. per square inch.

If the heat of compression could be removed as fast as it is generated, as with isothermal compression, the work required to compress unit volume would be represented by the diagonally-shaded area. This is the ideal condition. If the compression were carried out in one stage and no heat were removed—that is, if the compression were adiabatic—then the work required to compress unit volume of air would be represented by the total area of the diagram, that is the diagonally, plus the black, plus the horizontally shaded part. The ratio of this total work to that required in isothermal compression will be noted. If, again, the air were compressed adiabatically to 60 lb. per square inch only and then cooled to its initial temperature, its condition will then be the same as it would have been had it been compressed isothermally. From this point the second stage of compression is carried out and the cooling process repeated, meaning that the area of the second stage diagram is only the diagonally shaded portion plus the black portion, the horizontally shaded part being completely saved, due to the reduction in the volume of air dealt with, as a result of the intercooling.

Similar conditions obtain in the third stage, the horizontally shaded part again representing work saved. The work required for adiabatic compression in three stages is thus represented by the diagonally shaded portion plus the black portion, which latter represents the amount by which the work required is still in excess of the ideal.

Fig. 5 is the $\theta\ \phi$ diagram corresponding to the PV diagram in Fig. 4. The corresponding areas are similarly shaded. In addition to the work required, this diagram shows the temperatures attained in compression under the various conditions.

The reduction of the temperature due to staging is clearly shown. The 1,300 deg. F. is a theoretical value, 500 deg. F. is the temperature which would be attained were the compression carried out in two stages, and 330 deg. F. is the result of three-stage compression. In the case under consideration the total work is equally

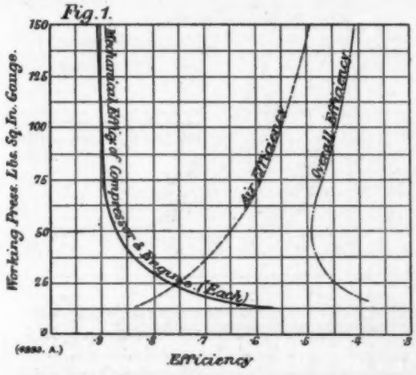
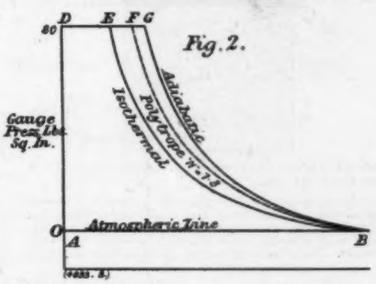


Fig. 1. Single-stage compressed-air power transmission. No preheating. Mechanical efficiency of engine assumed to be same as that of the compressor. Compression in compressor and expansion in engine assumed adiabatic.



Initial temperature of air ...	...	60 deg. F.
Initial pressure ...	...	... 14.7 lb. per sq. in. abs.
Final pressure ...	...	... 94.7 " " "

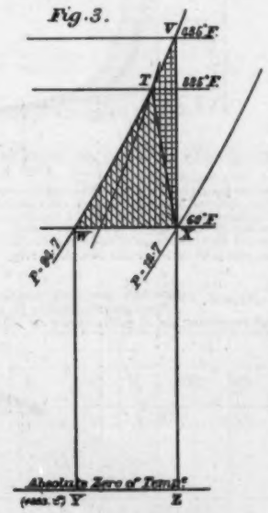
Work Required to Compress and Deliver 1 Cub. Ft. of Free Air.

(i) Isothermal compression	3950 ft.-lb.
(ii) Polytropic compression ("N"=1.3)	4950 "
(iii) Adiabatic compression	5275 "

In this case 30 per cent. more work is required for adiabatic compression than for isothermal compression. Hence note importance of cooling during compression.

Temperatures Attained at End of Compression.

(i) Isothermal compression	60 deg. F.
(ii) Polytropic compression ("N"=1.3)	335 "
(iii) Adiabatic compression	435 "



Temperature entropy diagram for compression of 1 lb. of air from 14.7 lb. to 94.7 lb. per sq. in. abs.
Heat equivalent of work required for isothermal compression = area WYXZ.
Heat equivalent of extra work required if compression is adiabatic = area VWX (vertical shading).
Heat equivalent of extra work required if compression is polytropic = area TWX (diagonal shading).
Heat equivalent of work saved by cooling shaded horizontally.

divided between the stages, whereas in actual practice this condition does not generally hold exactly.

The temperatures attained in the cylinder when air is compressed to various pressures in one, two or three stages, with intercooling, are given in Fig. 6. Piston friction and the effect of the cylinder walls have been neglected. As previously stated, the high temperatures could not be dealt with in practice. The temperatures given for two and three-stage compression are based on the assumption of perfect intercooling, which condition holds for well-designed machines. In some plants where there is a copious supply of cold water, and where intercoolers of liberal dimensions are fitted, the air can be

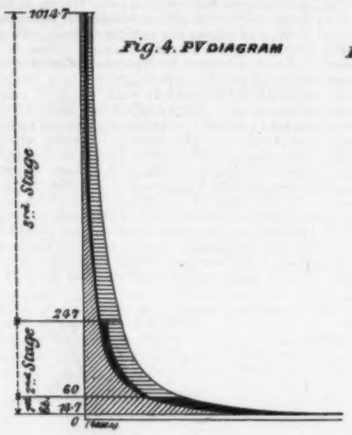


Fig. 4. PV DIAGRAM

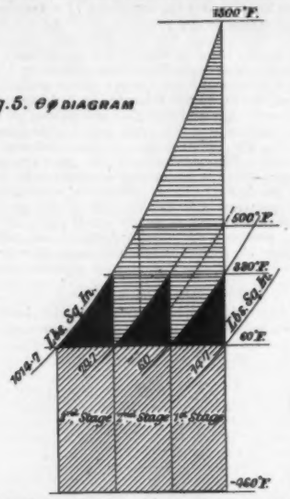


Fig. 5. θφ DIAGRAM

Theoretical Diagrams showing Saving Effected by Stage Compression. Compression to 1000 Lb. per Square Inch Gauge.

In an ideal compressor, *i.e.*, one in which compression is isothermal, the work required per unit of air is represented by the diagonally shaded area of each diagram. If compression were carried out in one stage the work required is represented by the total area of the diagram. The horizontally shaded area represents the work saved by compressing in three stages and intercooling. The darkly shaded area represents the amount by which the work required for three-stage compression is still in excess of the ideal. Note the huge saving of three-stage over one-stage compression. In this case the saving is 29½ per cent.

is as follows: The maximum terminal pressures are, for one stage, 80 to 100 lb. per square inch; two stages, 600 lb. per square inch; three stages, 1,500 lb. per square inch; four stages, 2,500 to 3,000 lb. per square inch; five stages, 4,500 lb. per square inch; and above 4,500 lb. per square inch, six or seven stages to 6,000 lb. per square inch, which is about the highest pressure for which an air compressor has been constructed.

In the case of very small machines these pressures, for a given number of stages are often exceeded in order to reduce complication. For example, machines have been constructed and work quite satisfactorily when compressing to 2,500 lb. per square inch in two stages. The

with AB—the volume dealt with in the same cylinder without clearance. The ratio $\frac{EB}{AB}$ is known as the Indicated Volumetric Efficiency, and in this particular case is about 69 per cent. The smaller the clearance space, the nearer will E be to A, *i.e.*, $\frac{EB}{AB}$ will be greater, and a larger volume of air will consequently be dealt with per stroke.

With a large clearance a larger cylinder is required to deliver a given amount of air than with a small clearance, yet the indicated work done per unit volume of air dealt with remains the same, although the larger cylinder makes for a heavier and more costly machine, with greater piston loads, so that in general practice the clearances are made as small as possible. Referring again to Fig. 8, the higher the compression is carried, the further will E be removed from A, that is, the higher the delivery pressure at which a given cylinder is working, the less will be the indicated volumetric efficiency. Further, if the clearance air receives heat from the cylinder and piston whilst expanding, the law of expansion will approach the isothermal and the pressure of the clearance air will take the longer to drop to the suction pressure, or E will be still further removed from A to G.

It is to be emphasised that the air should *not* receive heat whilst re-expanding, or, in other words, the clearance space should be as efficiently cooled as possible. The cooler the walls of the clearance space, the more rapidly will the pressure of the re-expanding air fall to the suction pressure and the greater will the ratio $\frac{EB}{AB}$ become. Moreover, if the clearance air receives heat whilst re-expanding, its temperature at point E will be considerably higher than the temperature of the in-

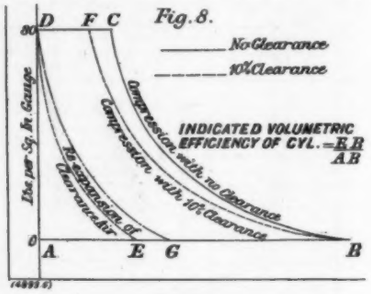


Fig. 8.

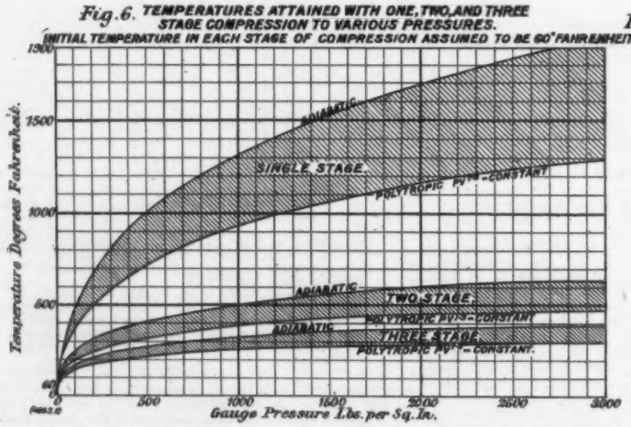


Fig. 6. TEMPERATURES ATTAINED WITH ONE, TWO, AND THREE STAGE COMPRESSION TO VARIOUS PRESSURES.

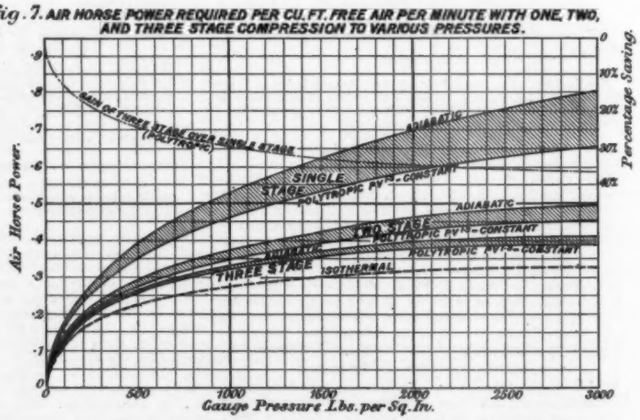


Fig. 7. AIR HORSE POWER REQUIRED PER CU. FT. FREE AIR PER MINUTE WITH ONE, TWO, AND THREE STAGE COMPRESSION TO VARIOUS PRESSURES.

cooled between the stages to less indeed than the initial temperature.

Fig. 7 gives the air horse-power required to compress 1 cub. ft. of free air per minute in one, two and three stages to various pressures, and shows how the power required approaches the ideal (isothermal compression), and the ill-effects of inefficient jacketing diminish, as the number of stages is increased.

For example, with air compressed to 1,000 lb. per square inch in one stage, according to the law $PV^{1\cdot3}$ = constant, the power required would be 0.46 a.h.p. per cubic foot; but if the cooling were very inefficient, so that the compression were adiabatic, the power would rise to 0.53 a.h.p. per cubic foot—an increase of 15 per cent. With three-stage compression, according to the same law, the power required would be 0.32 a.h.p. per cubic foot, and in this latter case, assuming that the cooling were inefficient, the power would only rise at the most to 0.335 a.h.p. per cubic foot—an increase of 5 per cent., against the 15 per cent. obtained when compression is carried out in a single stage.

Apart from the questions of efficiency and temperatures, an advantage of staging is the reduction of crank-pin loads and stresses generally—the reasoning being exactly the same in this connection as for a compound or triple-expansion steam engine. Theoretically an infinite number of stages is required, but practical considerations, such as the multiplicity of parts, the low mechanical efficiency, weight, cost, &c., limits the number of stages.

Pressures and Number of Stages.—The best practice

temperatures attained, however, make it necessary to carry out the cylinder lubrication by soapy water.

Effects of Cylinder Clearance Volumes.

An important consideration in the design of a multi-stage compressor is the computation of the clearance volumes of the various cylinders. By clearance volume is understood, not merely the volume of the space which separates the piston from the end of the cylinder when the crank is on dead centre, but, in addition to this, the volume of all valve ports and pockets, space behind piston rings if these are air-packed, and, in short, any space into which the air can be compressed without passing through the delivery valve. With an ordinary single-stage compressor, such as would be used to drive pneumatic tools in a shipyard, the designer aims to reduce the cylinder clearance to the minimum, for by so doing a greater quantity of air is delivered per stroke than would be the case with a larger clearance. Fig. 8, which is a theoretical card for a cylinder compressing to 80 lb. per square inch, is given in explanation. With zero cylinder clearance the volume of air delivered is represented by CD, whereas with 10 per cent. clearance and the same cylinder dimensions the volume delivered becomes FD. Less air is drawn into the cylinder per stroke, since the air left in the clearance space re-expands along DE, for a portion of the suction stroke, as shown, and the suction valves do not open to admit a fresh supply of air until the point E in the stroke is reached. In this way the volume of air aspired is only EB, as compared

coming air. As a result of the mixing of the new supply with the hot clearance air, the temperature at the end of the suction stroke, *i.e.*, at B, will be higher than it would have been had there been no hot air left in the cylinder at point E, thus reducing the weight of air dealt with per stroke and increasing the temperature of compression. In any case the temperature of the air at B must be higher than that of the suction air, owing to contact with the hot walls and piston.

In modern practice the cylinder clearance volume for a single-stage compressor or low-pressure cylinder of a multi-stage machine is seldom less than 3 to 4 per cent. of the volume swept out by the piston. It is usually found that, within limits for practical reasons, the larger the machine, the smaller the percentage clearance.

If a single-stage machine were constructed to compress to a moderately high pressure, say, 165 lb. per square inch, the indicated volumetric efficiency at the best would not be more than about 80 per cent., whilst the ratio of volume of free air delivered to volume swept by piston would be very much lower still, due to the addition of heat before compression commenced. Further, the crosshead loads would be very great, due to the final delivery pressure being exerted on the whole area of the large piston. The twisting moment diagram for the machine would be uneven, and, perhaps of most consequence, the final delivery temperature would be excessively high.

If, on the other hand, the same size of cylinder were used with a high-pressure cylinder added thereto, so that

the first only compressed to 37 lb. per square inch, the indicated volumetric efficiency would be increased to about 94 per cent., due to the lower delivery pressure bringing the point of the low-pressure diagram corresponding to E in Fig. 8 nearer to A. With the high-pressure cylinder mounted in tandem with the low-pressure, it is possible that the weight of the machine per unit of air delivered would not be more than when the compression was carried out in the one cylinder. Staging nullifies to a large extent the effects of clearance volume on the volumetric efficiency of a compressor, besides obviating the difficulties with loads and temperatures.

In both the French and German languages the expression for clearance volume, literally translated, means "injurious space," yet the effects of clearance in some cases are beneficial. In a cylinder with no clearance the whole load at the commencement of the stroke due to the acceleration of the moving part comes upon the crank-pin. With clearance, the re-expansion of the clearance air helps largely to accelerate the masses, and an interesting case in this connection may be cited.

With steam-driven compressors it is common practice to mount the steam cylinders in tandem with the air cylinders, in which case the setting of the steam valves must be so arranged that admission is late instead of early, as is usual. If the full steam pressure were applied to the piston before the clearance air pressure in the air cylinder had become reduced by re-expansion, unnecessarily high loads due to these simultaneous full pressures, less the inertia effects, would be imposed upon the connecting rods, &c. High speeds with increased inertia forces tend generally to reduce crank-pin loads. With steam-driven compressors of the foregoing type the greater the clearance volume of the air cylinder the later must the steam admission be timed.

Effects of Clearance in the Higher Stages of a Multi-stage Compressor.

In a multi-stage compressor the work done in the various stages may be varied within fairly wide limits merely by adjusting the clearance volumes of the various cylinders, excepting the low pressure. Suppose, for example, it is required to reduce the proportion of work done in the high-pressure stage of a three-stage compressor in which the high-pressure clearance volume is 10 per cent., and with stage pressures—low pressure 45 lb. per square inch, intermediate pressure 300 lb. per square inch—working against a final delivery pressure of 900 lb. per square inch.

The work done in compression varies as the ratio of final to initial pressure, so that any desired reduction in any given stage can only be effected by reducing this ratio, or in this case by increasing the high-pressure suction pressure, since the final delivery pressure is fixed. The compressor capacity being unaltered, an increase in the high-pressure suction pressure necessarily involves a corresponding reduction in actual volume of high-pressure suction. Since the volume swept by the high-pressure piston remains the same, it is clear that the only way to ensure a reduced suction volume is to decrease the volumetric efficiency of the high-pressure cylinder by increasing the clearance volume, with the result as shown in Fig. 9, where the high-pressure diagram with the original 10 per cent. clearance, together with the diagram resulting from an addition of 20 per cent. extra clearance, are given. The area of the diagram is considerably reduced, the high-pressure suction pressure (the intermediate-pressure delivery pressure) rises from 300 lb. per square inch to 375 lb. per square inch (gauge-pressure), this increase being necessary in order to get the whole of the air into the high-pressure cylinder. The effect on the low-pressure delivery pressure is slightly to increase it, due to the reduced volumetric efficiency of the intermediate pressure cylinder, resultant upon the expansion of the intermediate pressure clearance air from a higher pressure. The actual increase in low-pressure delivery pressure depends upon the intermediate pressure clearance volume. If the intermediate pressure cylinder had no clearance volume, which is impracticable, the low-pressure pressure would remain unaltered. The slight increase in low-pressure delivery pressure somewhat reduces the volumetric efficiency of the compressor.

The simple method of altering the distribution of work would be convenient where the high-pressure delivery temperature was found to be excessive (see later), or in cases where the turning moment was unsatisfactory. The clearance volume can be increased by the addition of a hollow pocket, but cannot so easily be reduced.

Fig. 9. Diagram showing result of increasing the clearance volume in the high pressure cylinder

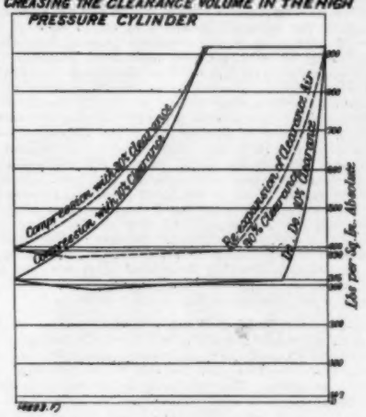


Fig. 10. 2nd Stage Pressure. *Fig. 11. 1st Stage Pressure*

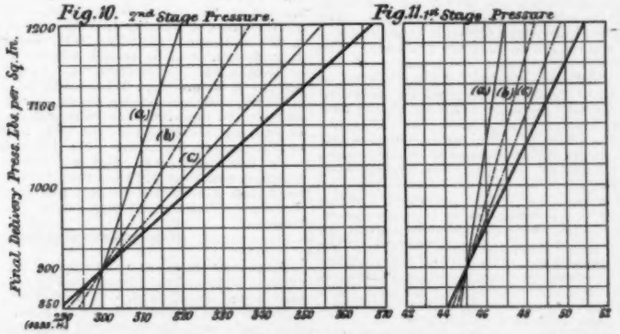


Diagram showing Approximately the Stage Pressures attained when the Compressor is Delivering against Different Final Pressures.

Each machine is designed for a final delivery pressure of 900 lb. per square inch with L.P. and I.P. pressures of 45 lb. per square inch and 300 lb. per square inch respectively.

(*a*) For a compressor whose clearance volumes are: L.P., 4 per cent., I.P., 5 per cent., H.P., 10 per cent. of volume swept by piston.
(*b*) For a compressor whose clearance volumes are: L.P., 4 per cent., I.P., 10 per cent., H.P., 20 per cent. of volume swept by piston.
(*c*) For a compressor whose clearance volumes are: L.P., 4 per cent., I.P., 15 per cent., H.P., 30 per cent. of volumes swept by piston.

The heavy line shows what the pressures should be if the division of work between the stages is to remain in the same proportion for all delivery pressures.

Some multi-stage compressors are required to work for long periods at varying delivery pressures, or, in the case of a charging compressor, at a constantly increasing pressure from atmospheric to the full bottle pressure.

With Diesel engines it is usual to regulate the blast pressure by throttling the fuel-injection air compressor suction, so that instead of compressing and blowing the excess to waste, only the requisite amount is dealt with. The effect on the distribution of work, temperatures, &c., occasioned by this throttling should be considered—especially with marine engines, where the compressor may run for long periods in this condition.

In all machines there are certain stage pressures which give the best all-round running, as regards temperatures, loads, balance, &c., for each delivery pressure. If these stage pressures are accurately determined for the normal final delivery pressure, then it is safe generally to assume that the particular stage division of work so obtained will also be the best proportion for any other delivery pressure at which the machine is likely to work. With Diesel engine fuel-injection compressors this state of affairs rarely obtains. In a three-stage compressor designed for 800 lb. per square inch working pressure, and run at, say, 900 lb. per square inch, the low-pressure and intermediate-pressure pressures will not increase in proportion to the final delivery pressure—actually in the majority of cases they alter little. By suitably proportioning the cylinder clearance volumes of the various stages the machine can be made automatically to divide the total work between the stages in a given proportion, no matter what the delivery pressure may be.

Figs. 10 and 11 show approximately the stage pressures which would be obtained in three machines of the same capacity when working at different pressures.

Each machine is designed for a delivery pressure of 900 lb. per square inch, and at this pressure the stage pressures are: low-pressure, 45 lb. per square inch, and intermediate pressure, 300 lb. per square inch (gauge pressure). The heavy lines on the diagram show what the pressures should be to secure an approximately constant proportional division of work between the stages. The lines marked (*a*) show the pressures which would obtain in a compressor having cylinder clearances of: low-pressure, 4 per cent.; intermediate-pressure, 5 per cent.; high-pressure, 10 per cent.

The rise in the stage pressures as the final delivery pressure increases is seen to be comparatively small. The lines marked (*b*) show the pressures with a compressor of the same capacity when the cylinder clearances are: low-pressure, 4 per cent.; intermediate-pressure, 10 per cent.; high-pressure, 20 per cent.

Here it is seen that the rise in stage pressures is much more marked than in the first case, that is to say, with these increased clearance volumes the proportional division of work between the stages is more nearly constant than with the smaller clearances. The lines marked (*c*) give the pressures which would obtain with a machine having clearances: low-pressure, 4 per cent.; intermediate-pressure, 15 per cent.; high-pressure, 30 per cent.

In this case the rise in stage pressures as the delivery pressure increases approximates much more nearly to the "ideal"; that is, the proportional division of work between the stages is very nearly constant, so that the balance of the machine is more likely to be maintained than in the first case, and, further, the final delivery temperature will be lower, for in the first case, when the machine is working at a pressure higher than its designed pressure of 900 lb. per sq. inch, the high-pressure stage is taking more than its designed share of the work. For example, if the first machine (case "a") were run at 1,200 lb. per square inch, the compression ratio in the high-pressure cylinder would be:—

$$\frac{1215}{335} = 3.63.$$

If the last machine (case "c") were run at 1,200 lb. per square inch, the high-pressure compression ratio would be:—

$$\frac{1215}{370} = 3.28.$$

This means that the temperature attained in the machine with the large clearance would be less than in the machine with the small clearance on account of the smaller compression ratio. Furthermore, if the large clearance is composed of a connecting pipe within a water-jacket, as is sometimes the case, the cooling *during* compression is improved, resulting in a decrease of the value of "n" in PV^n = constant, still further reducing the temperature. Again, the clearance space being so efficiently cooled results in an increase in the value of "n" for the re-expansion of the clearance air. The incoming air mixes with this comparatively cool air, and consequently the initial temperature is not unduly raised.

The main point, however, is that by correctly arranging the clearance volumes the machine can be made to divide the total work into the best proportions for any delivery pressure with which the compressor may have to deal. A minor point is that with increasing delivery pressures piston leakage becomes greater, and the volumetric efficiency at the higher pressures is less than at the lower. If the low-pressure pressure increases with the delivery pressure, the indicated volumetric efficiency of that cylinder is decreased in addition—or, in short, the overall volumetric efficiency of the machine with the big clearances is slightly less than that of the machine with the small clearances when the delivery pressure is higher than that for which the compressor is designed.

The difference, however, is not worth considering. (It may be mentioned that the lines in Fig. 10 should not actually be quite straight. They are sufficiently accurate, however, as in practice it is impossible to estimate the pressures to within a few pounds.)

(To be continued.)

American Machinery Exports.—The exports of machinery from the United States in July were valued at 18,971,052 dols., as compared with 11,412,691 dols. in July, 1915, and 8,060,614 dols. in July, 1914. The value of the shipments of metal-working machinery aggregated 7,814,091 dols. in July, as compared with 3,872,358 dols. in July, 1915. The exports of machinery of all kinds from the United States in the first seven months of 1916 were valued at 123,406,983 dols., as compared with 67,959,823 dols. in the corresponding period of 1915, and constituted an altogether new record. The last previous record was that for 1913 (76,830,444 dols.). The total of 123,406,983 dols. representing the value of American machinery exports in the first seven months of this year included 9,224,071 dols. for gasoline engines (against 3,061,395 dols. in the first seven months of 1915); steam engines, 5,697,812 dols. (against 1,933,113 dols.); all other engines, 3,109,225 dols. (against 557,791 dols.); parts of all other engines, 5,075,839 dols. (against 2,363,865 dols.); metal-working machinery, 47,152,401 dols. (against 23,962,815 dols.); milling machinery, 1,514,683 dols. (against 1,323,034 dols.); mining machinery, oil well, 1,122,709 dols. (against 781,849 dols.); all other mining machinery, 3,519,661 dols. (against 2,924,528 dols.); printing presses, 1,052,668 dols. (against 889,446 dols.); pumps and pumping machinery, 2,995,688 dols. (against 1,581,692 dols.); sewing machines, 3,222,701 dols. (against 3,683,751 dols.); sugar mill machinery, 1,954,068 dols. against 1,127,006 dols.); textile machinery, 1,995,143 dols. (against 1,019,724 dols.); and typewriting machines, 5,899,249 dols. (against 3,979,272 dols.).

CATALOGUES.

Small Dynamos and Motors.—Messrs. Higgs Brothers, of Sherbourne-road, Balsall Heath, Birmingham, have recently added a few new pages to their catalogue, copies of which they have sent us. They deal with variable speed, shunt and series-wound motors of from ¼ up to 30 h.p. Particulars are given of dimensions, shipping weights, spare parts, accessories and repairs, together with prices. All sizes of machine above 1½ h.p. have a full-load efficiency of over 80 per cent. The variable-speed motors up to 10 h.p. have a speed range of 1–2; above that the range is not quite so great.

Water Circulators for Boilers.—A leaflet from Messrs. "Perfecta" Boiler Circulator, Limited, of 25, Victoria-street, London, S.W., which we have just received, contrasts the working of a Lancashire boiler fitted with one of their devices with a plain boiler of the same type. The circulator, which can be erected without it being necessary to drill any holes in the boiler, takes the form of a horizontal baffle. The makers claim a saving in fuel of from 6 to 8 per cent.

Switchgear and Electrical Accessories.—Messrs. A. Reyrolle and Co., Limited., of Hebburn-on-Tyne, have sent us a binder containing leaflets illustrating several designs of their armoured switchgear, which has already been fully described in Engineering. The examples shown include switch pillars suitable for mining installations, on account of their flame and explosion-proof characteristics, and switchgear for sub-stations, in all of which the working parts can be easily removed for safe inspection or adjustment. The binder also includes price lists of cast-iron distribution boxes, self-aligning and switch-type fuses, plugs and sockets and oil-break switches suitable for mounting on switchboards.

Locomotive Cranes.—The Brown Hoisting Machinery Company, of Cleveland, Ohio, U.S.A., have sent us a copy of their Catalogue I, of locomotive cranes. It is really a collection of photographs of their cranes at work on all kinds of contracts and in all sorts of countries. Thus there are illustrations of machines in Norway, only 700 miles from the North Pole, in India, Russia, Spain and so forth. Only naturally most of the examples are taken from America, and here the cranes can be seen handling almost every conceivable class of material in slings, in grabs, in skips, and with magnets. They range in size up to 40 tons, and some have jibs as long as 75 ft. —for shipbuilding work. The catalogue is excellently printed and contains a description of the principal features of standard cranes.

Weighing Machines and Balances.—Two new catalogues, Nos. 1,001 and 1,002, issued by Messrs. W. and T. Avery, Limited, of Soho Foundry, Birmingham, give the prices and particulars for a great variety of weighing apparatus and include indexes to the other specialised catalogues of this firm. Some 30 different types of weighbridges, each of which is specially suitable for some definite purpose, are illustrated. Thus one has the standard set well back from the platform, to enable casks to be rolled by, another has a very shallow frame for installations in places where there is little depth of floor, and another has the steelyard below the level of the platform in order to accommodate such loads as large steel plates. There is an illustration of a machine for automatically weighing the quantities of materials used in manufacturing processes and a brief description of a 100-ton hydraulic testing machine. The balances and counter scales in List No. 1,002 are suitable for all kinds of shopkeepers and traders.

Fan Brakes or Dynamometers.—Messrs. W. G. Walker and Co., of Emery Hill-street, Victoria-street, London, S.W., have sent us a pamphlet describing Mr. Walker's patent dynamometer for measuring horse-powers. It is an extremely simple device, comprising a pair of arms, which are clamped on to the shaft transmitting the power to be measured. On to each arm there is bolted a plate, or vane, which, in churning up the air, absorbs the power. It is surprising what a large amount of power can be taken up in this way. Thus two plates, 17 in. by 8½ in. require nearly 60 h.p. to rotate them at 1,000 r.p.m. The arms of the brake have bolt holes at several different radii, so that the plates can be attached in appropriate positions, and several sets of plates are provided. All the plates, in all the positions, are carefully calibrated and a set of curves supplied with the brake. It is only necessary to take the speed of the machine and refer to the curve to determine the output in horse-power. This dynamometer has the great merits of simplicity and ease of application, while it is low in first cost and is very little influenced by external conditions. The pamphlet gives prices for brakes with nominal capacities of from 6 to 150 h.p.

Electrical Apparatus.—A number of leaflets relating to starters for direct-current and alternating-current motors, knife switches, horn-type switch fuses, brake solenoids for single-phase and three-phase circuits, and single-phase watt-hour meters, have been issued by the British Westinghouse Electric and Manufacturing Company, Limited, of Trafford Park, Manchester. A pamphlet illustrating and describing the electrification of a fairly large modern flour mill, which was previously driven by a single horizontal steam engine, has also reached us from this firm. The machinery on each of the four floors of the mill is now driven by a 110-h.p. motor of the three-phase slip-ring type, arranged so that all the motors can be started simultaneously by liquid starters. The motors are placed near the centres of the main lines of shafting and are connected to them by means of flexible couplings. Separate motors are used for driving the wheat-washing and conditioning plant, and also for the grain intake plant, sack hoists, packing machines, elevators, conveyors, &c. The running speeds of most of the machinery were increased from 15 to 25 per cent., with a corresponding increase in output, and we understand that the installation has now been giving highly satisfactory results for considerably over a year.

Mechanical Lubricators.—We have received from the Lunken Company, Limited, of 35, Great Dover-street, S.E., a catalogue giving full particulars of a mechanical lubricator made by the Richardson-Phenix Company, of Milwaukee, Wis., U.S.A. In these lubricators the oil is drawn from the reservoir by a pump and circulated through a passage in the lubricator body. This passage is provided with needle valves, which can be regulated to supply the required quantity of oil to each of the delivery pumps, and the quantity passing into these pumps can be seen through sight-feed glasses. The pump plungers have racks cut on them, and these racks gear with pinions mounted on a horizontal shaft which is given a reciprocating rotary motion by means of a rocking lever. A valve is provided in the circulating passage, so that by closing this valve the circulation is prevented and the whole of the oil entering the passage must pass through the needle valves, whereas normally the surplus oil flows back into the reservoir. In this way the supply of oil to the parts requiring lubrication can be temporarily augmented at any time without disturbing the adjustment of the needle valves for ordinary working conditions. Several other special features of the lubricator are referred to in the catalogue, and illustrations showing it applied to steam, gas and oil engines, air compressors, &c., are included. Prices are stated for lubricators with from 1 to 20 feeds.

Gas-Pressure Raising Plant.—Messrs. George Waller and Son, of Phœnix Iron Works, Stroud, Gloucestershire, have issued a catalogue of machinery made by them for raising gas pressures and for the transmission of gas at high pressures. The catalogue is divided into three sections, the first of which relates to "boosting" plants for dealing with large volumes of gas at relatively low pressures and raising the pressure throughout a district, or for increasing the supply at times of peak load. For this work high-speed fans driven by steam or gas engines, steam turbines, and electric motors are illustrated. The next section deals with rotary compressors of the exhauster type, which are suitable for pressures up to about 5 lb. per square inch, and are used for increasing the capacity of existing mains or delivering gas for long distances through mains of moderate size. In many places it is found convenient to link up outlying districts with large centres by laying high-pressure steel mains and transmitting the gas at pressures ranging from 5 to 20 lb. per square inch or more, the pressure being reduced at the end of the line by district governors. For this work compressors of the reciprocating type are recommended, and all the necessary plant and accessories for the purpose are included in the third section of the catalogue. Full particulars are given of the standard sizes of all the above-mentioned machinery, and numerous examples of all types are illustrated. Portable compressors for testing mains, and apparatus for drilling mains under pressure are also dealt with.

Gas Engines.—A pamphlet which has reached us from the British Westinghouse Electric and Manufacturing Company, Limited, of Trafford Park, Manchester, gives some particulars of their horizontal gas engines for industrial purposes and also includes the results of the tests of one of these engines supplied to the Neapsend Gas Works, Sheffield. The engine was fitted with the Westinghouse system of variable admission governing, which is illustrated and described in the pamphlet, as also are some other special features of the design. The engine, which was intended for a normal load of 30 brake horse-power, had a cylinder 11 in. in diameter, with a piston stroke of 19 in., and ran at 180 r.p.m. The gas consumption at 29.5 brake horse-power was found to be 17.7 cub. ft. per brake horse-power hour, while the consumption at 24.7 h.p. and 17.5 h.p. was 18 cub. ft. and 20.2 cub. ft. per brake horse-power hour respectively. The net calorific value of the gas used was 530 British thermal units per cubic foot in each case. Another pamphlet from this firm illustrates and describes the installation of an 82-h.p. engine of this type in a Derbyshire mill for crushing and grinding heavy minerals such as barytes and fluor-spar, into fine powder. Gas is supplied to the engine from a suction plant using either anthracite or coke as fuel, and the consumption of anthracite comes out at .86 lb. per brake horse-power hour. It is interesting to note that the crushed barytes is extensively used for adulterating paints, cloth sizing and canvas filling, and also for mixing with vulcanite and cheap rubber products. The fluor-spar is used in the manufacture of aluminium. The process of grinding these minerals is fully described in the pamphlet.

Pneumatic Tools and Air Compressors.—The Consolidated Pneumatic Tool Company, Limited, of Palace Chambers, 9, Bridge-street, Westminster, London, S.W., have issued some new circulars, among which one of the most noteworthy is that concerning the "Hummer" self-rotating hammer drill for rock boring. This is a plain hammer drill, with a cylinder 2¼ in. in diameter, fitted with a small rotary motor gearing with the drill chuck. The compressed air first passes through the rotary motor, which runs at a high speed, and then passes on to work the hammer. The rotating gear has a very strong purchase over the drill and looks as if it should not easily get out of order. The C-66 drill weighs 65 lb. and on a consumption of 82 cub. ft. of air, at 80 lb. per square inch, will drill a 1¼-in. hole 12 ft. deep. Two other circulars deal with small air compressors of the vertical and horizontal types. In both of these the air valves are light, tempered sheet steel rings, which work practically noiselessly and give a high volumetric efficiency. The makers guarantee these valves for a period of three years. The vertical compressors are rated at 3, 5 and 10 h.p., at 100 lb. per square inch pressure and run at from 500 to 600 r.p.m. The horizontal machines are made in 18 standard sizes, having capacities of from 51 up to 1,120 cub. ft. of free air compressed per minute and are arranged for steam or belt drive. A separate circular gives particulars of the "Duntley" portable electric tools, such as breast drills, grinding and buffing machines and small blowers. There is also an electric hammer drill, which is driven by a motor that will take either direct or alternating-current and should prove very handy for drilling in stone or concrete.

Permutit.—The new catalogue of United Water Softeners, Ltd., of Imperial House, Kingsway, W.C., refers to a long list of users of permutit. The list is headed by the War Office and Admiralty; then follow wool combers, silk manufacturers, dyers, laundries in large numbers, hotels, sanatoria, engineering and chemical works, electricity supply stations, and water works. Permutit, it may not be superfluous to point out once more, is an artificial zeolite. Zeolites may be described as complex aluminates, and silicates of the alkalis and the alkaline earths, characterised by the ease with which they exchange their metals and re-crystallise under modified conditions. Permutit is such a sodium compound. When hard water is filtered through a column of granular permutit, the calcium and magnesium salts to which the water owes its hardness react with the permutit; the calcium and magnesium are retained by the permutit, and sodium salts pass into the filtered water in their stead. The water can thus be deprived of its hardness, completely or partially; potable water should not be too soft. There was trouble first with ferruginous water; that has been overcome by filtering the water first through manganese permutit. The used permutit is subsequently regenerated by letting a solution of ordinary salt percolate through it, when the sodium again replaces the calcium and magnesium taken up. The iron treatment is used, for instance, at the Hooton works of the West Cheshire Water Company; the total cost of treating 1,000 gallons of water delivered to the consumer, including salt, interest on capital, depreciation, &c., is stated not to exceed 1d. The bacteriological purification by the chlor-permutit process is a novelty. When chlorine is used for disinfection, the unavoidable excess of chlorine has afterwards to be removed; this is now done with the aid of an iron salt, the excess of iron being in its turn removed by manganese permutit. The invention of permutit came from Germany. But all the permutit of the company sold since 1914 has been made in this country by British labour, and the only foreign directors are the well-known Danish engineers, Messrs. V. Hjort and J. J. Lassen.

American Railroad Exports.—The value of the exports of American railroad machinery, &c., in the fiscal year ended June, 1916, was 74,729,000 dols., as compared with 34,919,000 dols. in 1913–14. Cars figured in this year's total for 26,660,000 dols., against 11,178,000 dols.; rails for 17,687,000 dols., against 10,259,000 dols.; steam locomotives for 12,666,000 dols., against 3,692,000 dols.; electric locomotives for 455,000 dols., against 437,000 dols.; parts of engines, for 7,274,000 dols., against 3,357,000 dols.; switches and track *matériel* for 5,262,000 dols., against 2,534,000 dols.; sleepers for 2,435,000 dols., against 2,565,000 dols.; spikes for 1,399,000 dols., against 346,000 dols.; and car wheels for 742,000 dols., against 414,000 dols. Hitherto the chief foreign markets for cars have been Canada and Cuba; for locomotives, Cuba, Canada and Brazil; and for rails Canada, Australia, Japan, Brazil, Argentina and Cuba. Large quantities of freight cars and other *matériel* are, however, now being forwarded to Russia, while supplies are being sent to France and Spain, as well as to the older customers mentioned. Steel rails valued at 1,700,000 dols. were sent abroad in June; those despatched to France alone represented a value of 1,188,000 dols.

Supply and Demand of Rubber.—It is quite possible, says *The London and China Telegraph*, that in 3½ to 4½ years the available supply of rubber may not be sufficient to meet the world's demands, and a situation be created that would at least be interesting. Such, at present, is the forecast; what the reality may be remains to be seen. Figures of possible supply and consumption show that the world's output has expanded considerably, the increase in 1915 being 31.8 per cent., and that for the current year being estimated at 27.3 per cent. This rate is not likely to be maintained owing to the fact that from 1911 to the present time no very considerable further areas have been planted. The additional 214,000 acres brought into bearing this year is the largest increase there will be for many years to come. In fact it is estimated that between now and 1920 the total increase in the areas in bearing will be only 377,000 acres. The average yield per acre now stands at 336 lb., and in 1920 it may have reached 400 to 450 lb. This would give a world's output of from 300,000 to 330,000 tons, provided that the receipts of wild rubber were maintained. The question of consumption is more difficult. The average increase in the United States during the last six years was 24 per cent., and if that rate were maintained, in 1920 there would be a serious rubber shortage. Indeed, if the world's demand increased by 20 per cent. per annum 373,000 tons would be required in 1920. The question is as to whether consumption will reach that figure, and whether the output will turn out according to estimate.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

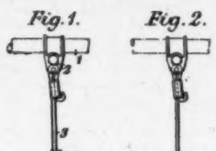
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 6d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Act.

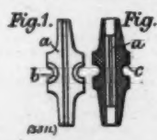
ELECTRICAL APPARATUS.

11,172/15. British Insulated and Helsby Cables, Limited, and J. W. Astley, Prescot. Overhead Conductors. (3 *Figs.*) August 3, 1915.—This invention has reference to means for suspending overhead electricity conductors from a support, generally a catenary wire. 1 is the catenary suspending wire; 2 is a suspending clip upon it; and 3 is the suspending wire to which the overhead conductor is to be fastened and suspended, and which, in the erection of the conductor, has to be bent at a particular point in the operation of fixing and suspending. 4 is a device which is adapted to be temporarily gripped or secured on to the wire 3, and which holds the overhead conductor 5 from the wire 3 temporarily by the chain 6, which is connected to the wire 5 by the clip 7. The holding device 4 is in the form of an angle-section bar; and the wire 3 lies within the angle; and at the upper part, where the wire enters the holder, it is recessed or



V-shaped; and opposite this part the fastening or clamping screw 9 comes, which screws through a projecting boss on to the wire, opposite the V-shaped rest, in which the wire lies. At the bottom end of the holder is a hook 11, in front of the body of the holder, and over which the end link of the chain 6 is passed. The holder 4, supporting the chain 6 and the conductor 5 will, in effecting the adjusting operation, be moved to the point on the wire 3 which will bring the conductor to the right height, and then gripped into the wire 3 by the screw 9. The end of the wire 3 is bent into a loop by a special tool acting in conjunction with the device 4, after the chain 6 has been passed on to the wire. The device 4 is then removed and the thimble 15 slipped over the loop (see Fig. 2). The free end of the loop is then turned down over the thimble to keep the same in place. (*Accepted July* 26, 1916.)

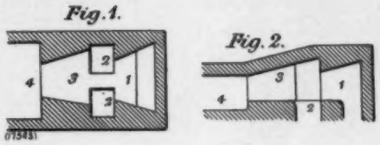
5,511/15. Aktiengesellschaft Brown, Boveri & Cie., Baden, Switzerland. Insulators. (3 *Figs.*) April 25, 1914.—The invention consists in the provision of a composite sleeve insulator in which the dielectric resistance at the part or parts next the socket is increased, either by using strata at that place wholly or partly at right angles to the main strata, in the case of a stratified insulator, or by choosing as material for the insulator a mixture of paper flock or fibrous material or mica, with synthetic resin, the part next the socket, the dielectric resistance of which is to be increased, being subjected to a pressure



considerably higher than that necessary for the purpose of merely shaping the insulator. In Fig. 1 a sleeve insulator is illustrated which consists of two parts, *a* and *b*. The strata of the part *a* surround the conductor in a concentric or spiral manner, whilst the strata of the part *b* (the insertion) surround the socket in part in such a manner that every line of force passing from the socket into the part *a* is compelled to cut through all the strata of the part *b*. In Fig. 2 the central part of the insulator *a* is formed of stratified material in the shape of a tube, and this is surrounded by non-stratified material *c*, pressed around the cylindrical core *a*, to an exceedingly high pressure. (*Accepted August* 2, 1916.)

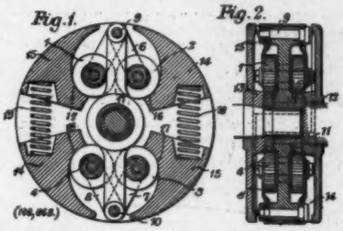
GAS-ENGINES, PRODUCERS, HOLDERS, &c.

17,343/15. E. W. Harvey, London. Gas Furnaces. (12 *Figs.*) December 15, 1915.—The gas delivery port 1 is contracted in the direction of the passage of the gas by inclining the sides and top of the port, and the air ports 2 are situated in front of this port, so that the gas passes at a high velocity between them, inducing the air and becoming intermixed therewith as it enters the mixing chamber 3. The mixing chamber is also contracted in the direction of flow by inclining its sides and top,



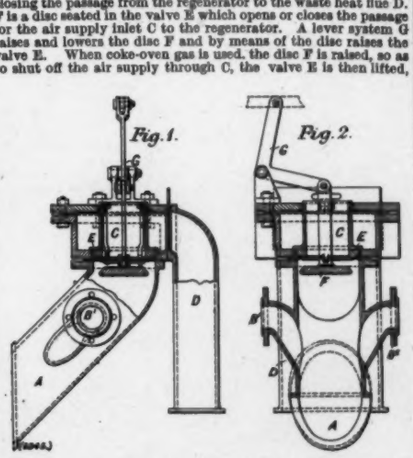
whereby the mixture is compressed and its constituents are still further mixed before the main combustion occurs in the furnace chamber 4. In this manner the development of heat begins nearer the entrance of the gases to the furnace than has hitherto been the case. (*Sealed.*)

100,868. L. Renault, Billancourt, France. Internal Combustion Engines. (5 *Figs.*) July 21, 1915.—The present invention relates to a device for automatically controlling the angle of lead of the ignition under all conditions of operation. The device comprises four masses, 1, 2, 3 and 4, which are secured to the end of four pendular arms 5, 6, 7 and 8, pivotally mounted in pairs on axes 9 and 10 carried by a central support 11 independent of the plates 12 and 13 and mounted on the controlling shaft. The plates 12 and 13 are provided with oppositely projecting sectors 14 and 15 provided with curved paths 16 and 17,



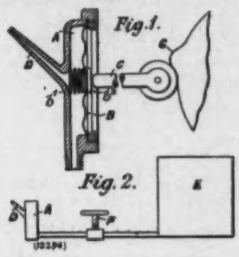
respectively, which masses 1, 2, 3 and 4, under the influence of centrifugal force, tend to move away from one another and to separate, by contact, the rolling path or paths 16 and 17, thereby causing the sectors 14 and 15 to produce the advance of the plate 13 controlling the magneto. Two springs 18 and 19 tend to bring the plates 12 and 13 back into their relative lagging positions. Instead of fixing the masses on an intermediate member, it is possible to fix the masses on the plates, the paths in which they move being cut in a symmetrical member against which the pendular masses bear. (*Sealed.*)

8,945/15. O. Imray, London. (*M. G. Christie, B.E.F., France.*) **Coke Oven Regenerators.** June 17, 1915.—The invention relates to valves controlling the supply of air and waste heat to the regenerators of coke ovens or the like. A is the connection leading to a regenerator, B^1 and B^2 branch connections to the gas main, C the opening for admitting air, D the connection to the waste heat flue. E is the valve opening or closing the passage from the regenerator to the waste heat flue D. F is a disc seated in the valve E which opens or closes the passage for the air supply inlet C to the regenerator. A lever system G raises and lowers the disc F and by means of the disc raises the valve E. When coke-oven gas is used, the disc F is raised, so as to shut off the air supply through C, the valve E is then lifted,



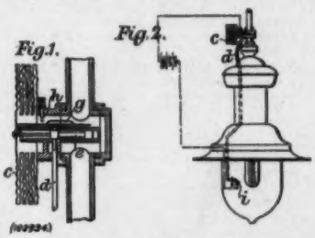
and the waste heat from the regenerators passes through the passages A and D to the waste heat flue for the required periods. The reverse action occurs when the air supply is to be heated, the valve E is then closed and the disc D lowered to allow air to pass from C into the regenerator. During these periods the connections B^1, B^2, to the gas mains are closed by the stop-cocks. When lean gas is used, certain regenerator chambers are allotted to heating the gas and others to heating the air. In those chambers in which the gas is to be heated the disc F is screwed to the valve E; for a certain time the gas cocks leading to the branches B^1, B^2, are closed and waste heat from the regenerators passed through the valve E and passage D to the waste heat flue. At the end of this period the valve E is closed and the gas cocks opened, so that the gas can pass below the valve E to the regenerator. (*Sealed.*)

10,254/15. P. G. Tacchi, New Wanstead, and The Centrum Syndicate, Limited, London. Internal Combustion Engines. (2 *Figs.*) July 14, 1915.—This invention relates to the supply of petrol or other fuel to internal combustion engines. According to the invention, the fuel is injected intermittently into the combustion or mixing chamber of the engine from a continuous feed without the intervention of valves cutting off the fuel. A is the fuel-box or chamber. B is a diaphragm. D is the nozzle from which the fuel is sprayed. E is a reservoir in which the fuel is maintained under constant pressure. F is a supply-regulating device. A spring b^1 presses out the diaphragm to meet the rod C actuated by a cam G on the engine to give an inward stroke to the diaphragm through the button b^2. The stroke may be varied by adjusting the position of the cam. The regulating device F may be in the form of a needle valve restricting the fuel passage under the control of the engine governor, so as to give a varying feed according to the requirements of the



engine. The needle valve may cut off the supply when the engine stops. The chamber A is therefore during the running of the engine always supplied with fuel at the required rate, and at each stroke of the plunger C a regulated quantity is driven through the nozzle D at considerable pressure at the proper point of the engine stroke. (*Sealed.*)

100,934. South Metropolitan Gas Company and J. M. Somerville, London. Automatically Igniting Gas Burners. (5 *Figs.*) April 15, 1916.—According to this invention, a slide-valve *a*, which is also a contact carrier, is employed actuated by a collapsible chamber *c*, preferably of the aneroid barometer type, to which gas is admitted in a manner to cause the chamber to



move the slide valve, when gas is turned into the burner, first to uncover the by-pass *d* and complete the circuit of an electric igniter *i* by means of the spring *g* and contact *k* and then, by a continuation of the movement in the same direction, to close again the by-pass and break the circuit of the igniter. (*Accepted August* 2, 1916.)

GUNS AND EXPLOSIVES.

100,935. G. C. Gibbs, Bristol. Gun and Rifle Sights. (3 *Figs.*) July 28, 1915.—The rear-sight comprises a vertically-adjustable standard *a* sliding upon a pillar *b* provided either as a substitute for, or by slightly modifying, the usual long-range aperture sight in which is formed the aperture b^1. The standard *a* of this rear sight consists of a hollow tube or frame being vertically adjustable on its pillar *b* by means of a milled head *c* and screw *d* engaging with an interior screw-threaded bore formed down or partly down the rear-sight pillar *b*. A milled set screw is also provided to enable the device to be locked in its adjusted vertical position. To assist in determining this, the vertical

tubular standard is cut or chamfered away along its front face so as to provide an edge or zero mark *f* which is adapted to co-operate with a zero mark or with other graduations formed on the inner rear-sight pillar *b*. The aperture *i* for the rear-sight is formed in a block *j* which is slidable along a horizontal bar *k* projecting outwardly from one side of the vertically-adjustable member *a*, and adjustment for wind may be made by means of a milled head *l* and screw, the degree of movement being registered by the provision of zero mark *m* on the sliding block *j* moving against fixed graduations on the horizontal arm *k*. (*Accepted August* 2, 1916.)

MOTOR ROAD VEHICLES.

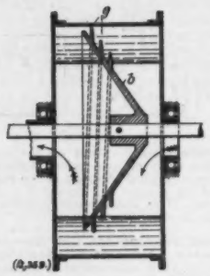
100,498. Michelin et Cie, Clermont-Ferrand, France. Detachable Disk Wheels. (4 *Figs.*) December 8, 1913.—According to this invention, the wheel is formed of a single metal

sheet comprising a thickened central portion 4, a coned portion 1 and an outwardly bent portion 2 forming one side of the rim. 3 is the other side of the rim; the parts 2 and 3 are connected together by means such as rivets. The thickened centre has

flat faces which can be bolted to the hub by nuts 6 screwing upon the driving studs fast with a collar 7. The bearing surfaces of the nuts are made spherical, so that if the nuts 6 are improperly screwed up and there is play between the disk and the hub they tighten themselves. (*Sealed.*)

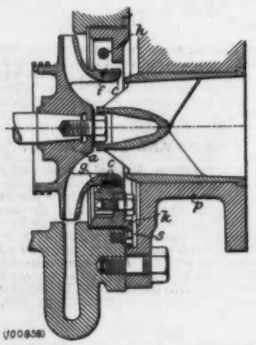
PUMPS.

12,359/15. J. Johnston and The Globe Pneumatic Engineering Company, Limited, London. Rotary Compressor. (3 *Figs.*) August 27, 1915.—This invention relates to rotary compressors or exhausters of the type comprising two members arranged one within the other and eccentrically to one another and having an annular liquid piston occupying the space between the members. According to this invention, the inner



rotary member comprises a disc *b*, which may be either radial or conical or inclined, and such that the liquid forming the piston has free access to both sides thereof, said disc being provided with one or two threads or helical or spiral vanes *g* set at an inclination to the face of the disc, so as to trap the air or gas being operated upon and force the same outwards over the edge of the disc. (*Sealed.*)

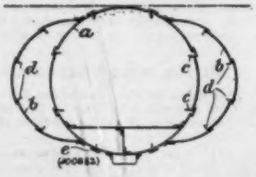
100,858. G. and J. Weir, Limited, and W. McCowatt, Glasgow. Centrifugal Pumps. (5 *Figs.*) March 29, 1916.—The invention consists in means for supporting, and adjusting the position of, the stationary collars of the labyrinth packing. *a* is the pump rotor, *b* the main part of the casing, *c*, *c*, the labyrinth collars on the rotor at the suction side, and *f*, *f*, the stationary labyrinth collars at the suction side. The collars *f*, *f*, are carried by the labyrinth ring *g*, which is made in two parts connected together by bolts. The two parts of this ring *g* are connected together round the boss of the rotor before the rotor is placed



in the casing. The ring *g* is held in place and its exact position adjusted by means of the solid or single-part ring *k*—which is screwed into the casing *b*—and the threaded pins *m*, *m*, which pass through holes in the ring *k* and are screwed into tapped holes in the ring *g*. The ring *k* and pins *m*, when screwed into place, lift the ring *g* off the rotor and adjust it to the desired position before the suction member *p* is placed in position and bolted to the casing *b* by the studs *v*, *v*. The ring *k* is serrated, and a locking-pin *s* whose head engages with one of the serrations is employed to lock the ring in the desired position. (*Sealed.*)

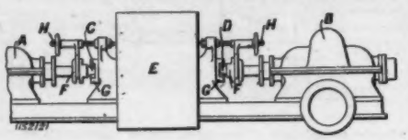
SHIPS AND NAUTICAL APPLIANCES.

100,862. H. E. Yarrow, Glasgow. Submarine Vessels. (4 *Figs.*) April 14, 1916.—According to this invention, the hull of a submarine vessel is formed of external plates connected by longitudinal and transverse butt straps adapted, without the addition of transverse frames, to stand the stresses to which the structure is normally subjected. The plates *a* form the internal



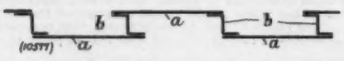
hull; the plates *b* form the external hull or ballast tanks, which extend over the greater part of the length of the vessel. In the example shown, every other plate of the inner hull is provided with a flange *c* at each edge, and every other plate of the outer hull with a flange *d* at each edge, but every plate may be flanged at one or both edges. The plates *a* are connected by longitudinal butt straps *e*. (*Sealed.*)

15,212/15. William Beardmore and Co., Limited, and J. Dornan, Dalmuir. Marine Turbine Installation. (1 *Fig.*) October 28, 1915.—The invention has for its object to utilise turbines of the type in which there are two oppositely-rotating rotors or members. In turbines of this class there are, of course, two driving shafts. According to this invention, means are provided for holding stationary when desired one of these shafts, and there are provided two installations of auxiliary machines, one coupled to each shaft and each of 50 per cent. of the normal full-load capacity, or each of such lesser than full-load capacity that the total capacity is 100 per cent. A, B are two centrifugal pumps having their impellers on or coupled to the two oppositely-rotating shafts C, D of a turbine E. The means of holding one or other rotor and the corresponding pump



impeller consist of dog clutches, one member F of each of which is splined or otherwise slidably mounted on the shafts C, D, while the other member G of each is fixed to the casing of the turbine E. Each clutch is controlled by handwheel-operated screw gear H. (*Accepted August* 2, 1916.)

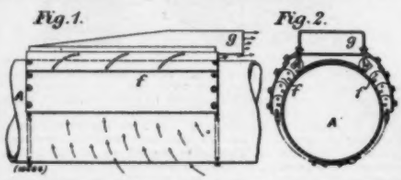
10,577/15. J. R. Barnett, Crookston, Renfrewshire. Ships' Bulkheads. (3 *Figs.*) July 21, 1915.—The bulkhead instead of being built with the plating arranged in one plane, and having the stiffeners on one or both sides of the plating, is built



with the plating *a* arranged "out and in" fashion, the amount of "out and in" being the depth required for the stiffeners *b*. The stiffeners *b* may be formed in one with plates *a* or, as shown, separate therefrom. The use of stiffening stringer plates and brackets is unnecessary. (*Accepted August* 2, 1916.)

STEAM-ENGINES, BOILERS, EVAPORATORS, &c.

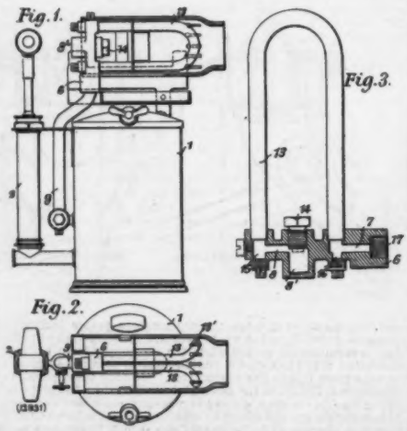
10,664/15. Circulators, Limited, S. J. Ross and H. Schofield, London. Boilers. (4 *Figs.*) July 22, 1915.—The invention consists in the arrangement upon the furnace flue A of a central hood or nozzle chamber *g* with two open-



mouthed saddle-like side chambers *f* that partially surround a portion of the furnace or flue, such side chambers being so formed that the area between the outer surface of the flue and the inner wall of the saddle-like chamber increases from the mouth of the chamber to the hood. (*Accepted August* 2, 1916.)

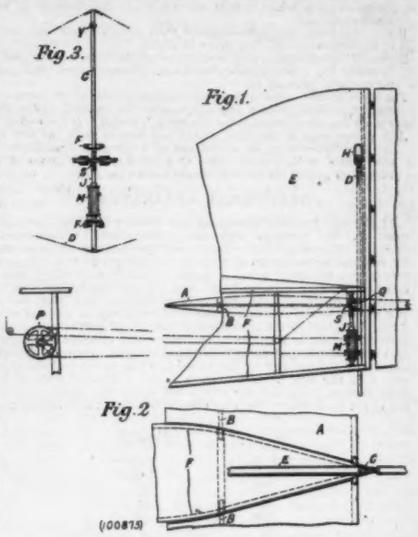
MISCELLANEOUS.

12,931/15. A. Kitson, A. Noblett and The Kitson Empire Lighting Company, Limited, Stamford. Burners for Vapour Lamps. (4 *Figs.*) September 9, 1915.—The drawings illustrate the invention as applied to a blow lamp. 1 is the fuel reservoir, 2 is a pump for compressing air into the reservoir. 6 is a part so formed as to constitute two closed chambers 7, 8. The fuel chamber 7 is connected by means of the pipe or tube 9 to the reservoir. 13, 13, are pipes or tubes bent U-shape, by means of which the fuel chamber 7 is connected with the vapour chamber 8. Each of the U-shaped pipes or tubes is bent near its free or looped part as at 13¹ so that when such pipes or tubes are in position on the chambered part the bends will be



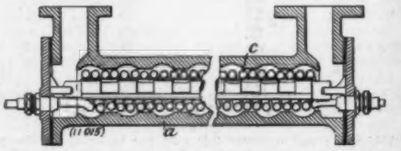
disposed outwardly relatively to each other. The vapour chamber 8 is furnished with the recess 8¹ to accommodate an accumulation of vapour and thus ensure a steady outflow thereof from the vapour chamber through the vacuum plug or nozzle 14, which is perforated centrally throughout its length and is preferably furnished with the gauze screen to keep the perforation in the plug or nozzle free from extraneous matter and thus prevent its being choked. 15 and 16 are apertures formed respectively in the vapour and fuel chambers for the enabling of an implement to be passed into the tubes 13 for cleansing purposes. 17 is a screw-threaded recess which serves for securing the chambered part 6 to the pipe 9 in the attachment of the burner to the fuel reservoir. (*Accepted July* 26, 1916.)

100,875. A. V. Roe, Manchester. Aerial Craft. (7 *Figs.*) January 5, 1916.—A represents the tail plane of an aeroplane, divided, of course, by the fuselage F, but pivoted thereon about the line B, B, and constructed with a strut C passing up through the fuselage F and between the canvas sides of the fixed fin E; these sides are cut away at H beside its top end to allow of the passage of the bracing wires D, D, to their connecting points on the plane A. By this means it is possible to raise and lower the plane A without interfering with its bracing mechanism. The spindle J works vertically in bearings on the fuselage F, and is provided with a threaded portion and a drum M, the latter connected by the cable with the operating drum P adjoining,



and worked by the pilot. Y is a guide bracket for the strut C, being attached to the stern post of the machine, thus providing that the movement of the strut is parallel to the spindle J in order not to affect its connection with the nut S, which nut is connected by the flanges of a guide bracket Q. It will thus be seen that both the strut C and the frame bars of the tail plane A are simultaneously moved by the nut S without interfering with their inter-connecting parts. (*Sealed.*)

11,015/15. The Hon. Sir C. A. Parsons, Newcastle-on-Tyne, R. Howe and S. S. Cook, Wallsend-on-Tyne. Cooling Liquids. (5 *Figs.*) July 29, 1915.—The invention consists in a cooling unit comprising one or more spiral tubes *c* (through which the cooling water is passed) surrounding a corrugated core A and enveloped by a tubular corrugated casing *a* in such a manner as to provide a passage-way for the fluid to be cooled in which the



stream-lines are repeatedly broken up and subdivided, and fresh layers of the fluid are brought into close proximity and contact with the convolutions of the spiral tube or tubes. Further, the enlargements in the casing bore are situated intermediately between the depressions on the centering core, so that in its passage through the cooler the fluid to be cooled will be repeatedly broken up across the cooling spiral or spirals. (*Accepted August* 2, 1916.)

Brazil.—Brazilian financial affairs are again approaching something of a crisis. The question which British investors in Brazilian bonds are considering is the possibility of Brazil resuming cash payments in August, 1917. It appears from current budgetary reports that the Brazilian Government is extremely anxious to resume cash payments at the due date as proposed in the prospectus of the funding scheme and now in course of development; but it is not altogether clear that the country will be able to do this when the time for resumption arrives. The estimated revenue of Brazil for 1917 is set down at 29,350,500*l.*, while the expenditure is estimated at 30,200,500*l.* The exports of Brazil last year represented a value of 52,970,000*l.*, while the imports of the 12 months were set down at 30,088,000*l.* The annual imports have exceeded the annual exports during each of the last 10 years, with the exception of 1913, when there was an adverse balance of 2,217,605*l.*

Virginian Manganese.—The Consolidated Manganese Corporation has taken over a recently-organised Virginian manganese ore property and is mining and shipping high-grade ore. The mine has been known as the Piedmont or Meyer's, and it is situated about 6 miles east of Lynchburg, Virginia. When formerly worked it has yielded 5,052 tons from one shaft, with a total output of about 30,000 tons of washed ore. The new company has already shipped from 750 to 1,000 tons of ore averaging from 45 to 55 per cent. manganese, 3 per cent. iron, 8 per cent. silica and traces of phosphorus. These details compared favourably with the production of Brazilian or Indian manganese mines. It is proposed to increase the output to 1,000 tons per month. New York capitalists are backing the enterprise and they have appointed Mr. C. M. Weld, of 60, Broadway, New York (formerly associated with the Tata Iron and Steel Company, Sakchi, India), as consulting engineer in charge.